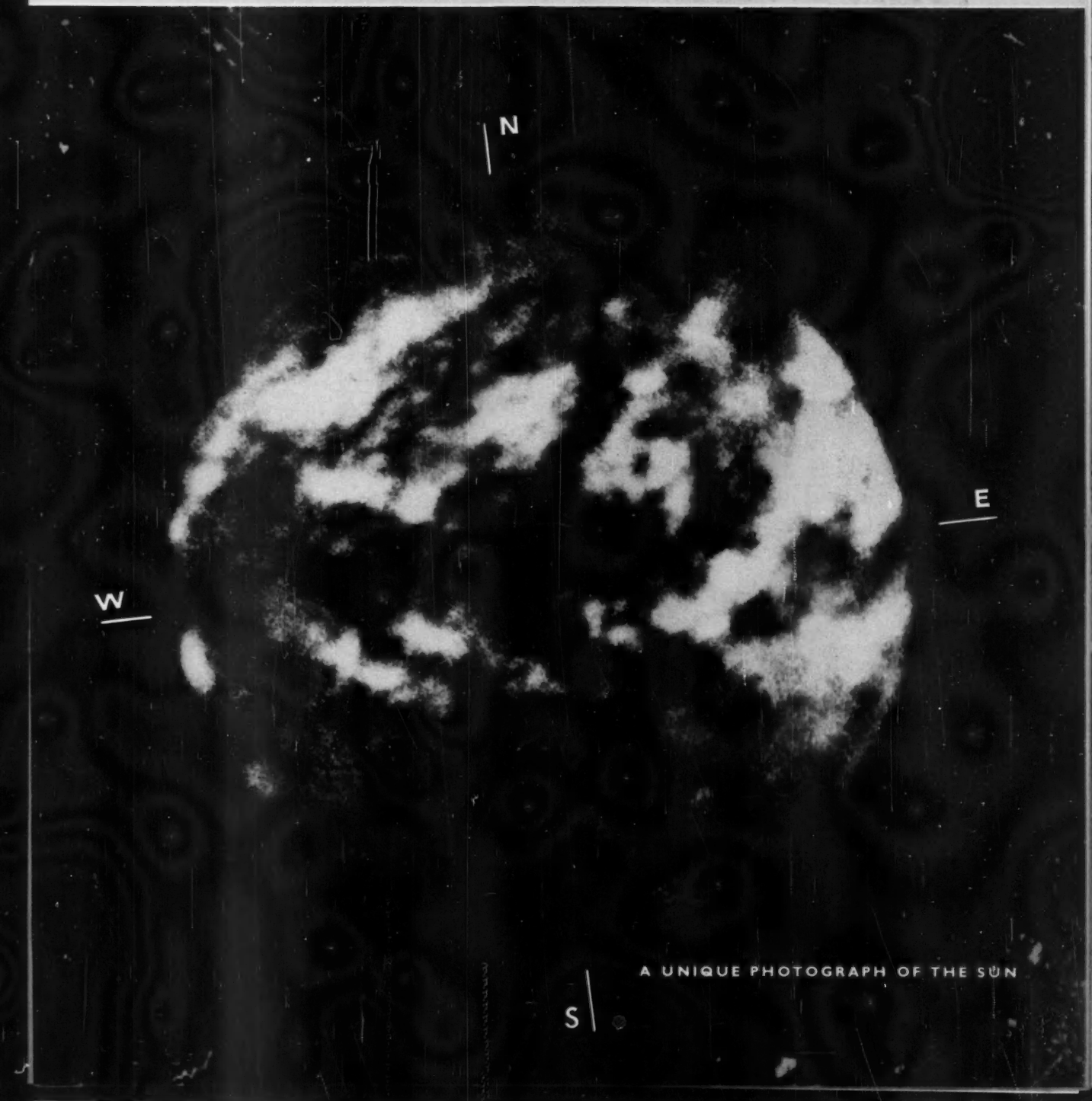
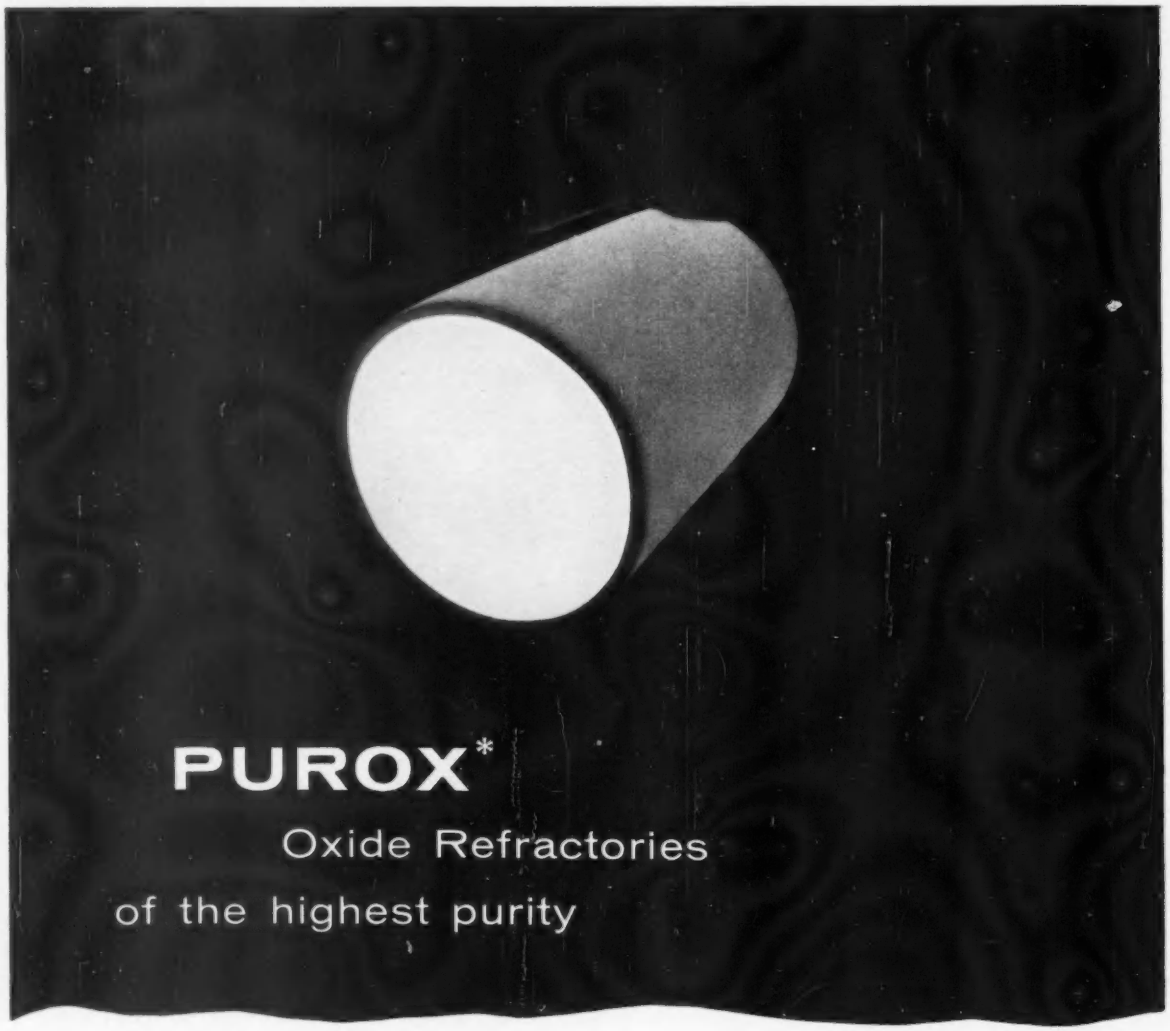
DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

JULY 1959 2/6



A UNIQUE PHOTOGRAPH OF THE SUN



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DISCOVERY

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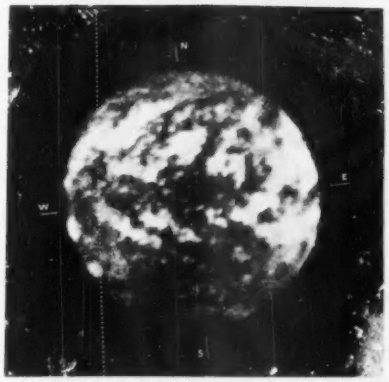
OUR COVER PICTURE



Scientists of the U.S. Naval Research Laboratory have succeeded in obtaining the first ultra-violet full photograph of the Sun. It was obtained by a special camera recovered from the nose-cone of a Navy *Aerobee III* rocket launched on March 13, 1959 at White Sands Missile range. The rocket reached an altitude of 123 miles where the light is midway between observable light and X-rays. Lyman α radiation formed the image on specially prepared photographic film.

The experiment was conducted during rocket astronomy work under the auspices of the International Geophysical Year.
(See p. 282.)

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Seeing

is believing . . .

Old sayings, it might be supposed, have no place in the ordered, logical world of science. Yet wherever research is concerned with phenomena outside the normal limits of human perception, the reliance placed by scientists on photographic methods of rendering visible the "invisible" bears out the essential truth expressed in "seeing is believing".

The pioneers of photography (scientists too in their own right) might nevertheless find it hard to believe their own eyes were they to be confronted with some of the results of modern scientific photography—but they could not fail to recognise the amazing progress in manufacturing technique which has enabled Ilford sensitised materials to play a leading role in so many aspects of present-day research.

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OUTLOOK UNSETTLED

Despite the generous rainfall in Britain there is a water shortage somewhere in the country each summer. However, this fact is not so surprising when we recall the importance of water to modern civilisation. Water is needed for everything: it takes 65,000 gallons to make a ton of steel; had the nuclear power programme required fresh water for cooling purposes, it would have been impossible to carry it through; public health, a balanced agriculture, and flood control are all factors in water-policy. Yet even more compelling is the scientist's vision: is it generally realised that 50,000 tons of water-vapour may be rising from one square mile of land on a mild summer's morning, and that the raindrops thus created may in the final analysis control all man's activities as a physical being? But the question, to quote a United Nations publication, remains "How far is man, in turn, the master of the rain?"

A report of the Central Advisory Water Committee has estimated that water consumption would rise about 25% over the decade 1955–65. The report stated that sufficient development schemes would be prepared to meet this demand. But there are still many problems: even if a proper balance between supply and demand is secured in the regions, there could still be difficulties locally. The growing demand of industry is unlikely to abate. Consumption, which in 1956 was around 46 gallons per day per head, must be compared with a not uncommon average of 100 gallons per day in the United States. The need to develop new, and often more costly sources of supply as water has to be carried longer distances, will increase pressure on the investment programmes, and will in time lead to a wider appreciation of water as a scarce commodity. The prospect of such development, which is quite normal in character and has nothing to do with expenditure for meeting extreme droughts, casts some doubt on the adequacy of the proposed figure for water investment in the 1959 Economic Survey. Yet outweighing all these considerations is the potential demand for irrigation purposes. Here it should be noted that in relation to full transpiration rate and plant growth, there is a deficiency of rain in more than five out of ten years south of the Humber–Severn line; that water used in irrigation is evaporated or transpired and cannot be re-used; and that in certain areas the demand for irrigation water could far exceed the demand made by industrial and domestic users combined.

The possibility of shortage causes much greater concern in the United States. It is worth recalling three striking facts: the demand of American industry for water has risen eight times in fifty years; the use of "higher-grade" ground water has trebled three times in fifteen years; during World War II the plans for building 300 military or industrial establishments had to be abandoned or modified because of inadequate supplies. Indeed very soon the availability of good water may become the most important factor in deciding where to locate industry: a far-seeing water-policy is thus necessary if American industry is to expand. Moreover, in America too, future estimates appear to be based on the rise of industrial needs and do not allow for a major change in the demand for water for irrigation.

The problem of water shortage is observed on the world scene in even more dramatic terms. A UN publication has pointed out that "unless adequate steps are taken, serious conflicts are likely to develop for the rights to all usable water supplies . . . in the arid and humid regions of the world". The importance of irrigation is seen by the fact that zones where rain seldom or never falls cover more than one-third of the earth's land area, presenting problems to no less than thirty-five nations. Flood control, too, poses a challenge: the tranquillity of rivers is too often taken for granted, yet in 1954, floods devastated 10% of China's total farm area. The challenge to health is equally dramatic: water is a carrier of disease (in India alone, 2 million people die annually from water-borne diseases) so much so that adequate water supplies and sanitation are prerequisites of economic advance in the countries concerned. Finally, there are the special problems of water pollution arising from industrial and other waste materials. All cities face this, and those which have no adequate system of waste-disposal, soon suffer the consequences in disease and poor living conditions. While sanitary engineering opens up great prospects including even the possibility that the sewage of big cities can, through the growth of algae, be turned to practical use to reduce man's lack of protein, there is also the threat to man and nature which these algae present in certain conditions. Moreover, as the power of industry grows, so, despite the many and not unsuccessful efforts to combat it, will the problem of pollution intensify, manifesting itself in varied and unexpected directions.

Despite work already done, more scientific information is needed. In Britain, for instance, hydrological surveys are required for certain areas. On a world scale, while we recognise the contribution of the World Meteorological Office in the International Geophysical Year, there is the continuing demand for more meteorological data, information about glaciers, pack-ice, and the nature of snow, and the possibility of a climatological atlas of the world. There is scope for research into the creation of rainfall, of the conversion of saline into drinking-water,* of the control of water-borne diseases, and, of special national significance, into water pollution. But the scientific effort must be within the right administrative framework. In Britain, hand in hand with the problem of creating a modern structure to replace some 1250 independent water-supply undertakings, there is the overriding task which requires long-term thinking, of ensuring harmony through location of industry policy between industrial growth and an economic water supply. The supply of fresh water and the preservation of related amenities are not problems which industry can be expected to resolve alone. Given Britain's need for planning, how much more urgent is the need for planning water resources on a world scale, and for strengthening the slender resources of the UN agencies already working in this field. For the problems of water supply and control are world wide, defying frontiers and extending over countries and continents.

* "Water for the World"; J. Jackson, p. 284.

ROYAL SOCIETY CONVERSAZIONE

This year's Royal Society Reception, given to its Fellows and other distinguished scientists, showed a high level of presentation and some exciting exhibits. A total of twenty-eight items were demonstrated and a very good film, *Radio Astronomy in Australia*, was shown. Prepared by the Commonwealth Scientific and Industrial Research Organisation Film Unit and supervised by S. T. Evans, the animation work and photographs were excellent, though the sound-track was rather poor. The film was welcomed by all who saw it as an excellent demonstration of Australia's contribution in this important field of science.

Mammals found beneath Trafalgar Square, by Dr J. W. Franks, University Museum, Manchester; Mr M. P. Kerney, Imperial College of Science and Technology, London; and Dr A. J. Sutcliffe, British Museum (Natural History).

The presence of remains of mammals no longer living in Britain, including hippopotamus, lion, and elephant, in old deposits of the River Thames, in the St James's Palace, Trafalgar Square area, has been known for more than two hundred years.

As long ago as 1731 a molar tooth of an elephant was discovered at a depth of 22 ft. below the surface when digging a sewer in Pall Mall, and further mammalian remains have since been found in Waterloo Place, and beneath Drummonds' Bank, Trafalgar Square (1879); the Admiralty (1890); Lloyds Bank, Pall Mall (1922); the Canadian Sun Life Assurance Building, Cockspur Street (1927); and Rex House, Lower Regent Street (1939).

During 1957 further animal remains, associated with fragments of plants, were found as the result of excavations for the foundations of the new Uganda House, on the south side of Trafalgar Square.

The mammalian remains, for the most part, are isolated bones swept down by the river and deposited in its bed. The animals represented are the hippopotamus, the straight-tusked elephant, a rhinoceros, a large wild ox, red deer, fallow deer, and the lion, to which list may be added a bear, bones of which were found near by in 1927. The fossilised dung of a carnivorous animal suggests that hyenas may also have been present at this period.

In the same deposit were shells of some sixty species of land and river molluscs and, in a layer of peaty silt near the base of the excavation, remains of insects (some still retaining the bright colours of life), and stems and seeds of over 150 species of plants, many no longer native in Britain.

From a study of the various remains it has been possible to reconstruct in some detail the conditions prevailing in London at the time that the deposits were being laid down by the river. All the evidence points to the climate having been warmer than at present.

The Pleistocene Period, or Ice Age, is divided by geologists into a series of Glacials and Interglacials, the former corresponding with major advances of the ice sheets, and the latter being the warm phases. The plant remains obtained from Trafalgar Square show that the deposit dates from the Last Interglacial Period, probably about 100,000 years ago.

(*Above*) Photograph of the south side of Trafalgar Square, London, where some remains were found when the foundations of Uganda House were dug in 1957.

(*Below*) Mammalian remains found at depths ranging from 15 ft. to 30 ft. below the present-day ground-level of Trafalgar Square. *Top row (left to right):* a metacarpal of a wild ox (*Bos primigenius*); a metacarpal of a red deer; a metatarsal of a fallow deer; the base of an antler of a red deer. *Bottom row:* part of a molar tooth of an extinct straight-tusked elephant (*Palaeoloxodon antiquus*) (found in 1922 a short distance from the site of the recent discoveries; a canine tooth of a hippopotamus and (*above*) a foot bone of a lion.

Electronic Models in the study of Cell Interactions, by Dr R. J. Goldacre and Mr D. Bean, Chester Beatty Research Institute, London.

The model exhibited consists of an artificial "tissue", or group of artificial electronic "cells" which can communicate with and influence one another.

Its behaviour resembles, in some aspects, the behaviour of groups of cells in the animal where communication between cells seems to be important, such as in the co-ordinated growth of a developing egg into an adult animal; and in nerve networks in the brain.

The co-ordinated growth which occurs in a developing embryo, and which involves the control of pattern and shape and determines whether the fertilised egg will grow into, say, a frog, fish, or snail, contrasts with the uncoordinated growth seen in malignant tumours. The hypothesis was developed that co-ordinated growth in the normal animal was to some extent a result of the passage of information and growth-controlling impulses from cell to cell by direct contact, growth proceeding by a kind of "brain-like" interaction of the cells in the organism. The model was built to show the feasibility of this hypothesis, stimulation coming from recent findings that tumour cells have different cell surfaces from the normal, and do not form firm connexions with one another and so would escape from this kind of control.

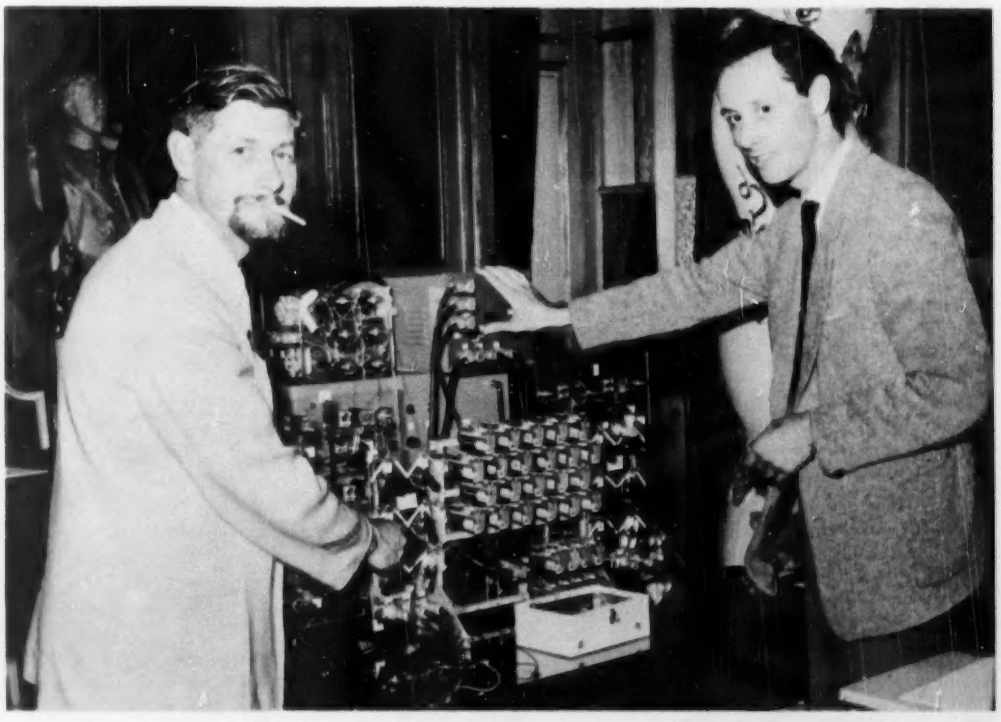
With the model it is possible to imitate and illustrate various processes in morphogenesis, for example, to show: how it is possible to generate a head–end or head–tail polarity in a developing egg from a group of cells which are all equivalent and connected together in a symmetrical way; how shape could be controlled in a growing pattern of tissue, according to a built-in "heredity"; how cells could become different from their neighbours; how regeneration of a lost part could occur; how reproduction of organisation could occur; and a possible basis of left- and right-handedness. In order to make it possible to follow easily the changing patterns of activity of the model it was arranged for each "cell" to emit a different musical note as it became activated.

The group of interacting cells in the model has some properties associated with nerve networks in the brain, and can be used to illustrate some "brain-like" phenomena. For example, according to Freud's theory of art, a tension in the brain seeks to find some outlet in useful activity, or if these channels are blocked, it may express itself in some artistic way.

Tensions in the model may be represented by electric charges in condensers which can be made to actuate a device for connecting up "nerve cells" in various pathways (as if seeking an outlet), and for firing pulses into such networks; and the pattern of activity generated can be followed by the musical sounds emitted.

Various interesting melodies and rhythms can be generated, and, by introducing disturbances, can be made to change and gradually find their way back to the original theme.

In several other ways the "nerve nets" are interesting in connexion with music; for example, if connexions between the "cells" are made and broken in various ways, as if exploring various avenues for discharge, pulsations can be generated in various "cells" with certain networks, the property of the network is such that the frequency of pulsation changes (on changing the connexions between the cells) in the ratio of small whole numbers, as is the case in the pitch and rhythm of music.



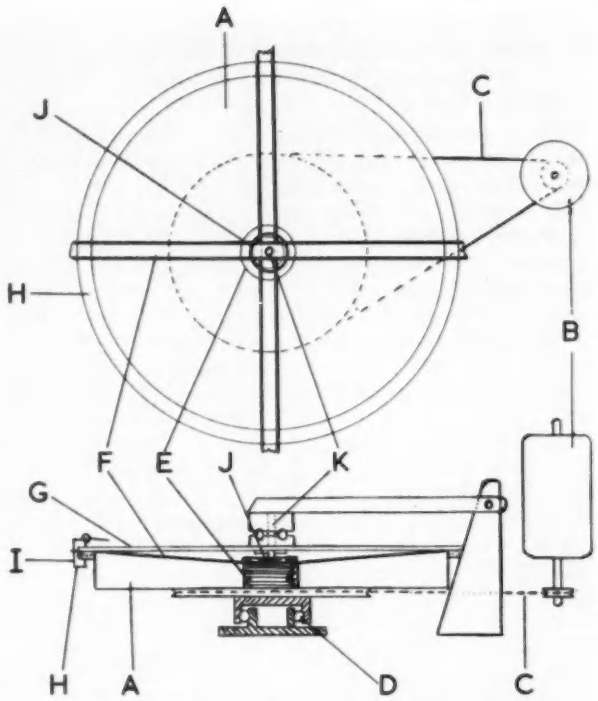
Dr R. J. Goldacre and Mr A. D. Bean with their electronic pattern-generator which simulates cell-cell interaction and morphogenesis.

Centrifugal Acceleration of Paper Chromatography, by Dr J. R. Tata and Mr A. W. Hemmings, National Institute for Medical Research, Mill Hill.

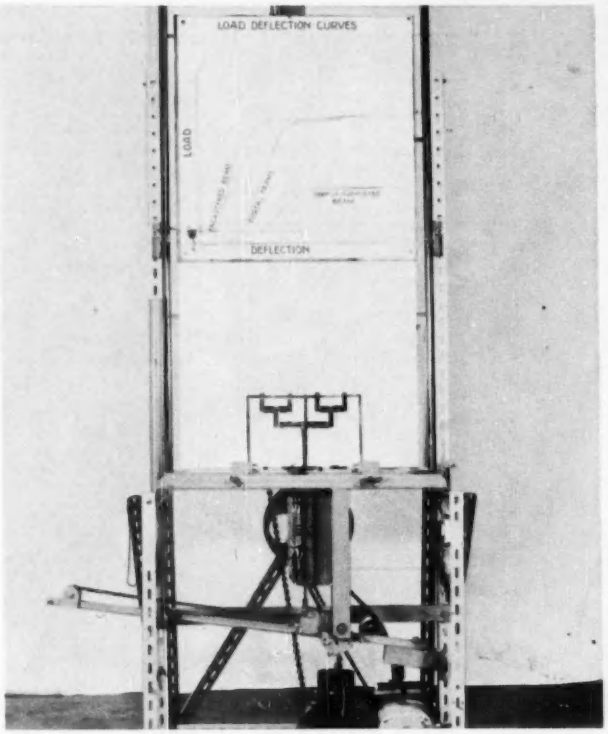
The separation and identification of minute amounts of many substances such as vitamins, hormones, sugars, amino-acids, metals, and so forth, by paper chromatographic analysis is now widely used in biochemical research. The principle of the method depends on differences in solubilities of substances to be separated which will make them move to different positions on filter-paper when water or a mixture of water and organic solvents flows through the paper. The time generally needed for the separation or "development" of chromatograms is between 15 and 24 hours.

In recent years chromatography and the labelling of substances with radioactive isotopes have jointly become a powerful tool in studying the biosynthesis and metabolism of substances of biological and medical importance. However, the time required for developing a chromatogram may be a serious handicap in experiments with rapidly decaying radioisotopes. In order to overcome this difficulty a simple apparatus has been constructed.

The apparatus consists of a basin in which filter-paper strips are arranged like the spokes of a wheel. The mixtures to be analysed are applied to the strips near the central reservoir of the chromatographic solvent and dried. The basin is sealed and rotated, which leads to an increased rate of flow of the solvent. In this way the usual period of development of 16–18 hours has been reduced to about 30 minutes. Centrifugally accelerated chromatography has now been successfully used for the rapid separation of substances labelled with radioactive bromine and iodine, thus making it possible to obtain extra information in the short period when radioactivity is still detectable. This technique might also be useful in the field of antibiotics.



(*Above*) Schematic top and side views of the apparatus used for centrifugal acceleration of paper chromatography. (*a*) aluminium dish; (*b*) motor; (*c*) belt; (*d*) bearings; (*e*) inner cup packed with filter-paper discs soaked in the chromatogram strips laid diametrically across the dish; each strip carries two samples spotted about 2 cm. away from the edge of the reservoir cup; up to twelve strips can be fitted; (*g*) Perspex lid; (*h*) dish rim; (*i*) clamp; (*j*) Perspex ring to provide good contact between strips and reservoir discs; (*k*) hole for capillary tubing through which additional solvent can be introduced.
(*Below*) Apparatus for centrifugal acceleration of paper chromatography.



(*Above*) Autographic testing machine with rectangular portal frame ready for test. The board shows typical load deflexion curves drawn by the machine for (*a*) a simply supported beam of rectangular cross-section subjected to form equal loads; (*b*) the same beam, similarly loaded but with ends *encastré*; (*c*) the same beam, similarly loaded but forming part of the portal shown in the photograph.

(*Below*) a model house, storey height 10 in., in which the bedroom floor is made of ½-in.-thick steel plate 12 in.× 6 in., carrying as bedroom furniture a 10-lb. block of lead. On the ground floor is a Morrison shelter, the framework of which is made of 22 SWG (0·028 in. thick) steel. Outside the house on the left is a heavy thick-walled "shelter" of brittle material.

Plastic Behaviour of Steel Structures, by Prof. J. F. Baker, Engineering Department, University of Cambridge.

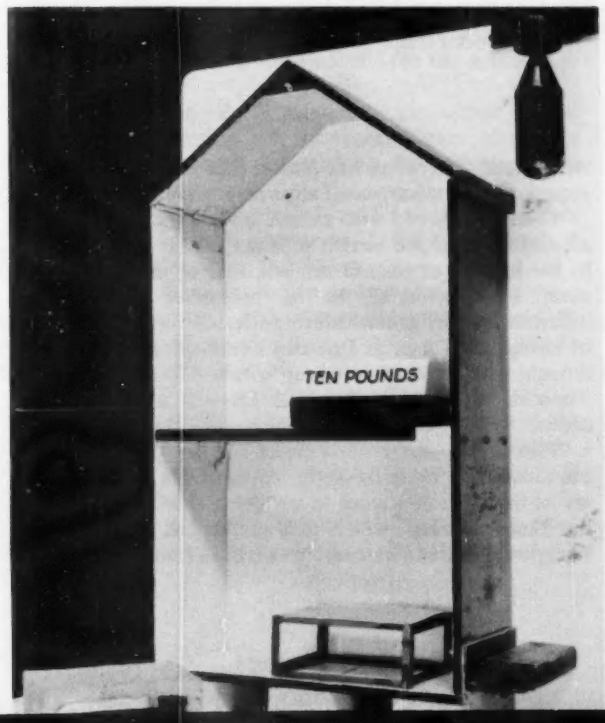
The behaviour of steel framed structures in the elastic range is extremely complex. Designers have in the past, therefore, been forced to use rule-of-thumb methods. A rational method of design leading to great economies has recently been developed based on the behaviour at collapse due to the formation of plastic hinges.

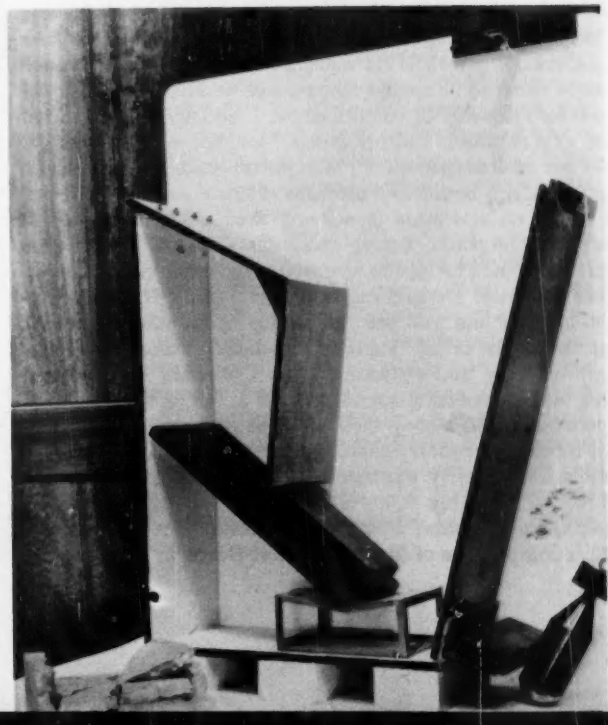
A testing machine has been developed to show deflexion as an increasing load is applied to three structures: a simply supported beam; the same beam but with its ends fixed; and the same beam forming part of a portal, the columns of which are the same size as the beam.

The first beam collapses at a load W, due to the growth of large deflexions, when a plastic hinge is formed at the centre. The second carries twice the load ($2W$) because collapse cannot occur until plastic hinges are formed at ends and centre. The third looks weaker than the second but it also carries $2W$ because again collapse cannot occur until plastic hinges are formed at ends and centre.

All the successful air-raid shelters provided after 1940 were designed by the "plastic method". A model showed a house collapsing on to an indoor shelter. When a shelter, however "strong", is made of brittle material it shatters. When, however, it is a light steel portal, for example, the "Morrison" shelter of which 1,270,000 were in use during the war, plastic bending absorbs the energy and successfully protects the occupants.

(*Below*) When a bomb falls just outside the house the right-hand wall is pulled out by the suction wave following the explosion; the bedroom floor falls, pivoting about its left-hand end, and strikes the Morrison shelter. The shelter, being a continuous ductile structure, does not disintegrate but deforms, absorbing the energy of the collapsing house by a small amount of plastic bending. On the left can be seen the state of the brittle "shelter" after being subjected to the same treatment.





WEDGWOOD AS A SCIENTIST

Just 200 years ago Josiah Wedgwood set up on his own as master potter and began his "countless experiments" which stamped him as a genius and the first scientific potter. Birmingham has a very special interest in this anniversary, for Wedgwood was one of the people who carried the name of that city to Europe and America as home of the Lunar Society. "Lunaticks" they were called by Matthew Boulton's butler; but Boulton himself saw this group, gathering at "l'hôtel de l'amitié sur Handsworth Heath", as Birmingham's answer to scientific societies in London and abroad.

When Josiah Wedgwood began his experiments early in 1759 he founded the science of ceramics. While Wedgwood pottery has been written about on countless occasions, too often it has been the artistic side which has been fully explored. Wedgwood, the only potter in history who was elected Fellow of the Royal Society on his merits as a man of science, made mortars and pestles of "chemical stoneware" first for Priestley and then for the chemists of Europe; these were the results of his 1759 experiments. He made crucibles and retorts for them, and sent to Lavoisier and other French scientists his pyrometer or measurer of "degrees of heat" of a kiln or furnace.

Wedgwood made the decisive step in his career when he set up in business on his own, and began his "suite of experiments at Fenton Hall" as he wrote. His brother had refused to take him on as partner, for he took a poor view of Wedgwood's "flights of fancy" as he called those original ideas which turned Wedgwood to science. Wedgwood had gained nothing from joining with Harrison of the Cliffe Bank Works, had ended his partnership with Whieldon, while Spode as an apprentice was too young to influence Wedgwood's work.

All this flux in his affairs ended when, with a small pottery at Ivy Works, Burslem, and a few workmen, Wedgwood began his researches, and his hundreds of trials with new mixes and materials. He made copious notes on all experiments and found reasons for the failures. Wedgwood set about changing old-fashioned formulae and ideas when he saw how pottery had become stagnant in outlook. "I saw the field was spacious, and the soil so good as to promise an ample recompense to anyone who should labour diligently in its cultivation." And so, with that kind of genius which Edison called "one per cent inspiration, 99 per cent perspiration", Wedgwood tried out new glazes, colours, new bodies and methods of firing pottery.

With no education in science, Wedgwood developed to a scientific potter, noting every detail of his experiments. He rang the changes in raw materials, tried various clays, barium from Derbyshire, china-clay from Cornwall, and manganese and iron ore for producing his unglazed black stoneware he called "basaltes". With cobalt from Plymouth, growan clay and soapstone from Cornwall, he increased his wares, analysing such materials as far as his chemistry permitted, and testing their value in pottery. He made use of barium carbonate, named "witherite" after Dr Withering, the Lunar Society member whose hobby was geology. By 1765 he made his "Queen's Ware" as a fitting product of the Queen's Potter, a title he had received a year earlier. This composition of flint and whitest Devon or Cornish clay

FIG. 1. Portrait medallion of Josiah Wedgwood.

was glazed with what was almost flint glass to give it that superior finish unsurpassed anywhere.

When Wedgwood died he left several thousand samples all classified for the benefit of ceramics. He had graduated in the hardest of science schools, that of practical experience. But above all let us remember Birmingham's influence on this Staffordshire potter, the invaluable effect of having such men as Priestley and Watt as friends. It is thought that Dr Small, a Lunar member, introduced Wedgwood to Watt, while Erasmus Darwin, as Wedgwood's doctor, in suggesting that the master potter should install a Watt engine, not only brought engines to the Potteries but farther, to the mills of the textile north. This bicentenary of the birth of science in pottery is thus bound up with the Lunar Society, which met at the full moon so that Wedgwood and others could travel back home more easily.

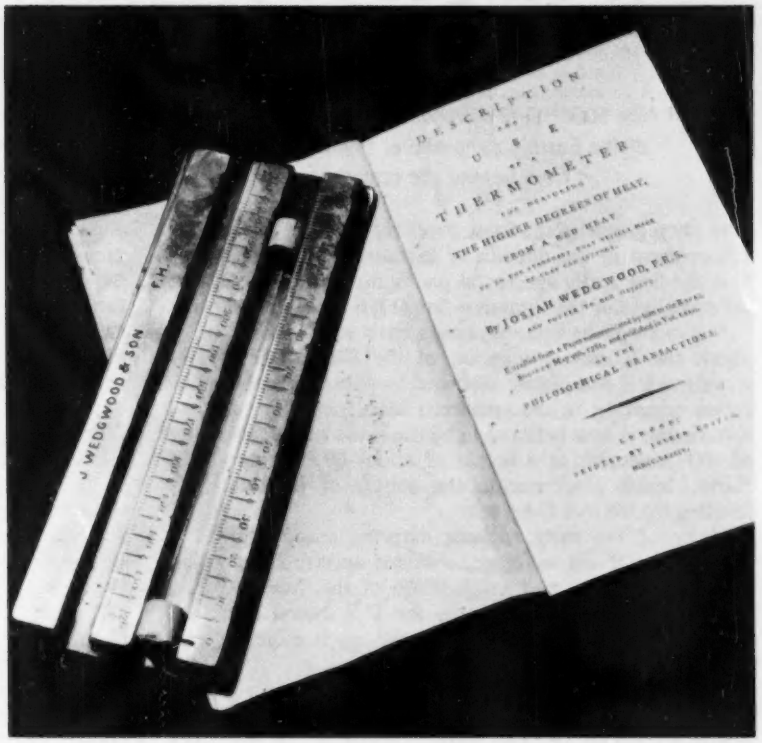


FIG. 2. The "thermometer" invented by Josiah Wedgwood, F.R.S., is based on the progressive contraction during firing of ceramic cylinders, whose diameters had been individually adjusted to give a zero reading before firing. The gauge is a measure, therefore, of contraction, and each of its units is in fact equivalent to $\frac{1}{4}\%$.

A scale intermediate between the Fahrenheit mercury scale and his own high-temperature scale was devised, using the thermal expansion of silver measured in a fired ceramic gauge similar in principle to the illustrated metal gauge. He correlated the intermediate scale first with the Fahrenheit scale up to the boiling-point of mercury, and then with his own scale. That he overestimated the Fahrenheit equivalents to his scale can be attributed to the fact that the initial contraction of his ceramic pieces is relatively slow. In other words, the temperature interval represented by the first five points on his scale is considerably higher than the same number of points in the middle of the scale.

He also attempted, unsuccessfully, to affect a correlation using an ice calorimeter as a measure of the heat in, and therefore temperature of, his cylinders.

SODIUM CHLORIDE AND CIVILISATION

Ordinary table salt, sodium chloride, may have had a considerable part in the evolution of civilisation.

Apparently there is no need for it in the diet of healthy people beyond the amount present in natural foodstuffs. Yet many people develop an extreme craving for more—so much so that wars have been fought to assure an adequate supply. This craving may, in a way, be similar to that which some individuals develop for alcohol—for the action as a stimulant.

The effect apparently is related to the action of the adrenal glands, causing the increased release of certain hormones which have far-reaching secondary effects throughout the organism.

This thesis is presented by Dr Hans Kaunitz of Columbia University in an article appearing in the recent Annual Report of the Smithsonian Institution.

Requirement of salt in various pathological conditions is quite a different matter, and in normal health man can do with little. The same apparently is true for animals, which, nevertheless, sometimes develop a craving for it.

It is thought that the stimulating effect of salt sets in motion adaptive mechanisms involving enlargement of the liver, kidney, and adrenals; this has been found in experimental animals. Similar conditions have been discussed in many other stress conditions.

"The possible changes, especially perhaps in the emotional sphere, brought on by the stimulating action of salt are, of course, entirely a matter of speculation. The greater responsiveness of people, if they were so stimulated, could have helped throughout the ages in the accumulation of knowledge. Whether this is one of the roots of the reverence which was accorded salt by the ancients can scarcely be guessed at this time.

"Is there reason to assume that the constant use of salt has changed our intellectual capacity? . . . One must assume that man in the Upper Palaeolithic period (10 to 35 thousand years ago) did not salt his food; yet Cro-Magnon man created magnificent art. Intellectually, therefore, he was our equal. He differed from us only in his lack of knowledge. Thus, although salt-eating did not change man intellectually but may have facilitated learning, it possibly was an important historical force."

Both physicians and public-health workers sometimes recommend certain levels of salt in the diet and there is a sound basis for prescribing low-salt diets in many diseases, particularly those involving the circulatory system. When it comes to normal people, however, recommendations are infinitely more difficult. It is certainly true that the chemistry of the body does not require the addition of salt to our food. The physician, however, is not primarily interested in the mere metabolic processes but in the general welfare of his patients, and he should consider that the quickened pace of a more complicated society demands persons with a heightened responsiveness. Salt may be one of the ingredients producing this effect.

A UNIQUE PHOTOGRAPH OF THE SUN

M. A. ELLISON

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For 6000 years astronomers have observed only what can be seen through the semi-opaque blanket of the Earth's atmosphere. Under the IGY programme an astronomical photograph has been taken from beyond the atmosphere for the first time, and the door opens on a new science.

The photograph on the front cover represents a remarkable achievement in the domain of extra-terrestrial astronomy. It is the first really successful photograph of the Sun's disc taken in light of the Lyman α-line (1216 Å) of hydrogen.

For many years astrophysicists have sought information about the Lyman α-emission of the Sun. Light of this wavelength is completely absorbed by photo-ionisation processes occurring in the terrestrial ionosphere. The Lyman α-radiation is now believed to be the cause of the ionisation of NO molecules at a height of about 80 km. above the Earth, which gives rise to the supply of free electrons forming the normal D-layer.

Many of the early rockets, carrying spectrographs to heights of 100 km. or more, obtained spectra from which the great intensity and small width of this line could be measured. From 1956 onwards the U.S. Naval Research Laboratory have been attempting the much more difficult task of photographing the whole solar disc in Lyman α-light. This required more precise instrumentation as well as accurate guiding by means of a "sun follower" to achieve a well-defined image. The present picture is the most successful outcome.

In the recent experiment the camera and film were recovered from the nose-cone of a Navy *Aerobee III* rocket launched on March 13, 1959, at the White Sands missile range. The photograph was taken from a height of 200 km.

In the picture we see numerous bright areas which are the regions of the Sun's disc from which Lyman α is being emitted most strongly. As is well known, the Lyman α-line is due to an electron transition from the two-quantum state to the one-quantum (normal) state of the hydrogen atom (Fig. 3): the Hα-line (6563 Å) arises from a transition between the three-quantum and the two-quantum states. The Sun's atmosphere consists of about 90% hydrogen. We should therefore expect that those regions which emit most strongly in light of the Hα-line (the so-called *plages* which show up in the filter pictures round active sunspot groups) would emit even more intensely in Lα. A comparison of the Lα picture and the Hα picture (Fig. 2) for the same day (March 13) shows that this is the case. It is clear that there is a close correspondence in the positions of the emission regions due to the two lines, but that the Lyman α-regions are much the more extensive. It will also be observed that there is little Lyman α-emission from near the north and south poles of the Sun where active sunspot regions are absent. There is also a general deficiency south of the equator where there were few sunspots at the time.

In the Hα photograph several "dark filaments" can be seen in projection against the disc. These are the prominences—long ribbon-like filaments of absorbing hydrogen gas which extend upwards into the corona. These Hα-filaments are found to coincide precisely with dark lanes separating the bright Lα-regions, which probably indicates that they are also opaque to Lα-light.

Future photographs of this kind, taken from virtually outside the atmosphere, will be awaited with interest, for they will reveal how the intensity of solar Lyman α varies during the course of the sunspot cycle. This one picture suggests that it will probably turn out to be closely dependent upon the sunspot number (R). One could also wish to see such a photograph taken at the time of a great solar flare.

In 1957, as part of its IGY programme, the Naval Research Laboratory launched rockets into the D-region when intense flares were known to be in operation. The special detectors which were then carried showed that the sudden increase of ionisation which takes place in and below the D-layer at the time of a flare is brought about by X-rays (wavelength 1–8 Å) emitted from the flare region or from the corona above it. The corresponding detectors for Lyman α did not indicate any great increase.

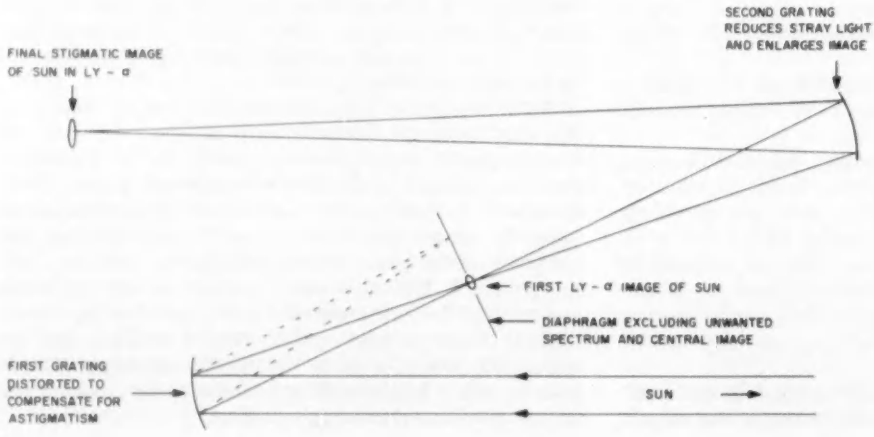


FIG. 1. Lyman α solar disc camera.

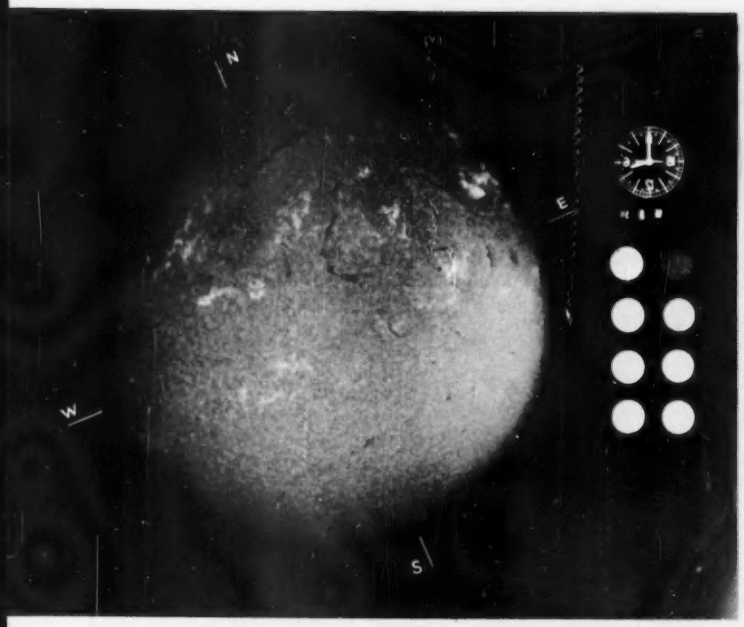


FIG. 2 (*left*). Photograph of the Sun taken in light of the Hα-line, Royal Observatory, Cape of Good Hope, March 13, 1959, 0700 UT. This picture was taken with the Lyot Heliograph and may be compared with the Lyman α image recorded by the U.S. Naval Research Laboratory rocket on the same day.

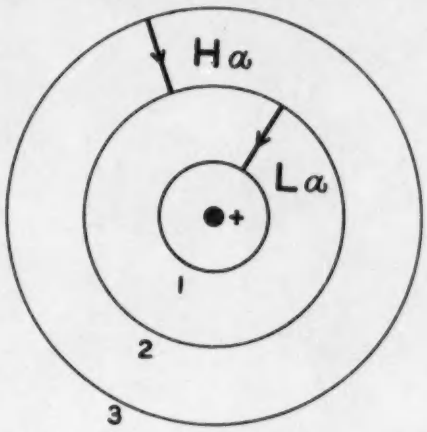


FIG. 3 (*above*). Hα-emission (6563 Å.) Lα-emission (1212 Å.)

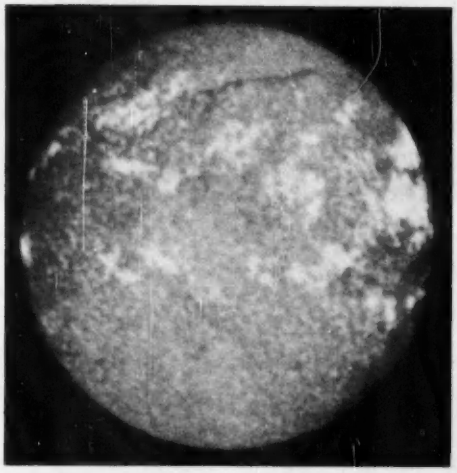
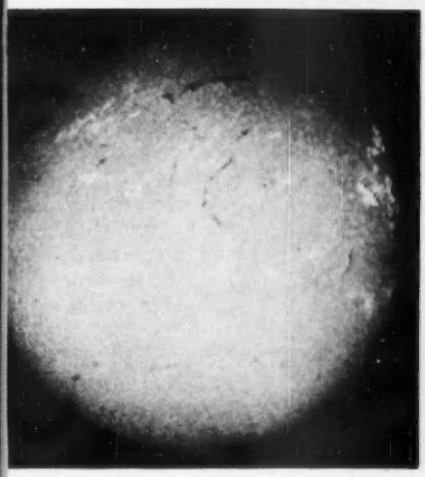


FIG. 4 (*extreme left*). Rocket picture taken in hydrogen (Lyman α) light.

FIG. 5 (*left*). Picture in light of calcium (K-line). This is in the violet region of the spectrum, just beyond the visible. Photograph taken by McMath-Hulbert Observatory, Pontiac, Michigan.



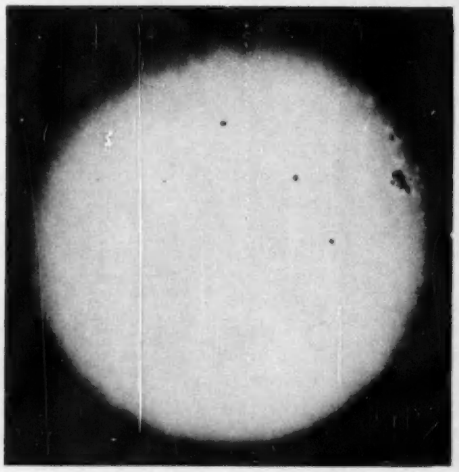


FIG. 6 (*extreme left*). Photograph in hydrogen (Hα) light, red end of the visible spectrum. Photograph taken by the U.S. Naval Research Laboratory, Washington.

FIG. 7 (*left*). Sun in white light, showing sunspots. This is the full unfiltered spectrum. Photograph taken by the U.S. Naval observatory, Washington.

All these photographs were taken on March 13, 1959.

(Photographs 4 to 7 by courtesy of the United States Navy)

WATER FOR THE WORLD

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The world-wide increase of population and spread of industry are bringing a steadily increasing demand for water. If salt water could be purified cheaply the problem would be solved.

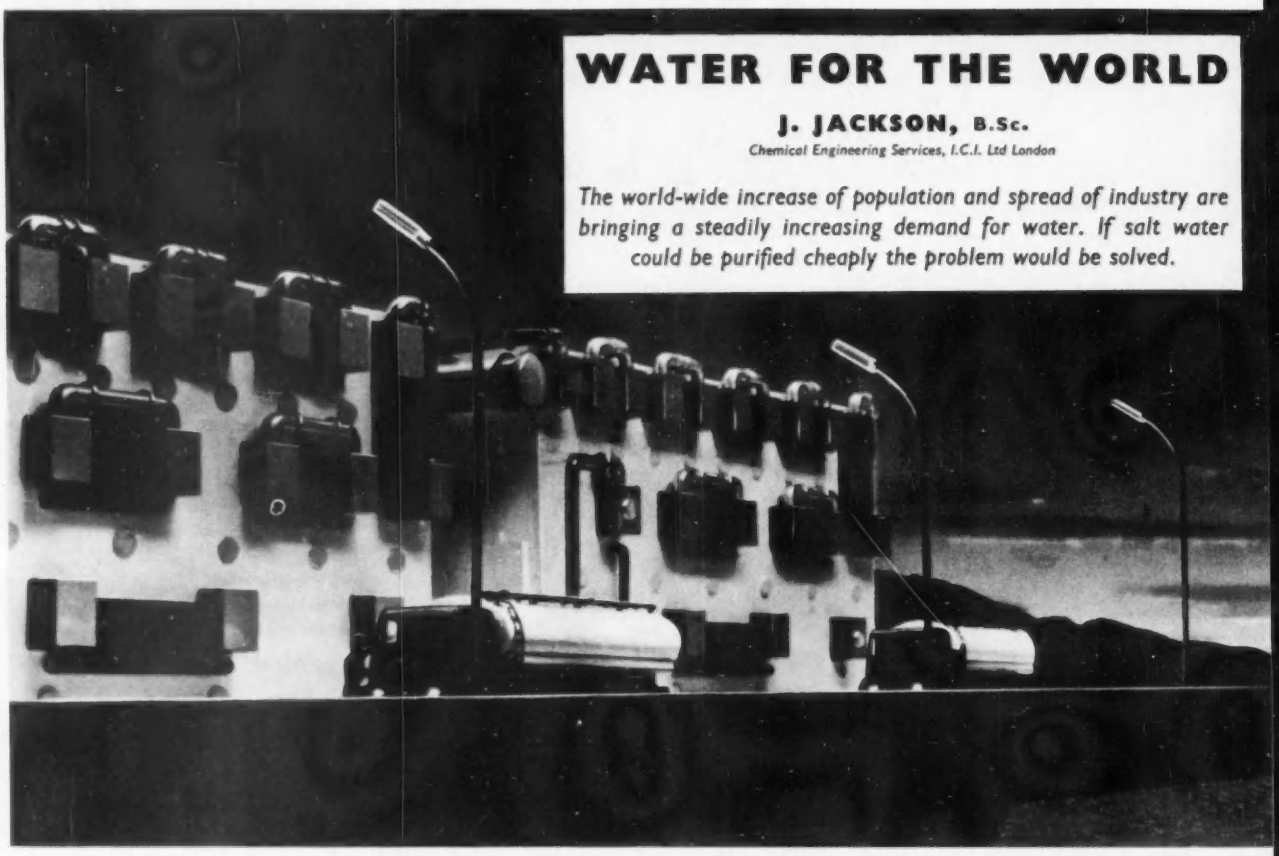


FIG. 1. An impression of one of the new "Multiflash" sea water evaporation and distillation plants, made by G. & J. Weir Ltd. of Glasgow. Each of the two units shown in the plant illustrated would give an output of a million gallons of fresh water daily, but can be designed to give outputs from 1 million up to 5 million gallons a day. Thus the output possible from a battery of units is virtually unlimited.

(Photograph by courtesy of G. & J. Weir)

Obscured by such more widely publicised developments as that of atomic energy, a technological revolution is quietly taking place which may very well change fundamentally the way of life of people in many parts of the world. In a number of countries research is being directed towards the development of a cheap method of producing fresh water either from sea water or from less salty, brackish water. There is little doubt that this research must ultimately be successful, and it is easy to imagine the striking transformation of the vast arid areas of the world which could result.

THE PROBLEM

Countries apparently well endowed with supplies of fresh water, like our own, are finding that, with the continued growth of industry, even these supplies are not inexhaustible. It is not surprising, therefore, that the research effort in "saline water conversion", as it is called, should be international. In the United States, for example, there is the Office of Saline Water, which is responsible for quite an extensive programme of research. In Europe, research in a number of countries, including Great Britain, is co-ordinated by a committee of OEEC. France has its own Commission de Déssalement des Eaux Saumâtres, which is an offshoot of the Conseil Supérieur de la Recherche Scientifique. In South Africa, which has its own peculiar saline water problems, research is carried out by the South African Council of Scientific and Industrial Research, and other countries, such as Israel, Sweden, Germany, and Italy, have made their contributions.

What is lacking so far is any co-ordination of this research on a world scale. This might well be something which could be undertaken under the auspices of the United Nations. Up to the present, however, while both UNESCO and the United Nations Department of Economic and Social Affairs have shown an interest in the problem, they have confined themselves to producing reviews of published work. What is also missing is an international journal on saline water conversion in which the results of the many investigations now in progress could be published. At present, many publications take the form of Government reports which are not always readily available outside their country of origin.

Research has so far been concentrated mainly on two very different processes: evaporation and electrodialysis, which are discussed in more detail later. These processes are complementary rather than competitive, since evaporation appears to be preferable for treating sea water and

electrodialysis for treating brackish water. In addition, however, work is in progress on a wide variety of other techniques such as freezing and solvent extraction.

EVAPORATION

The evaporation of sea water to produce fresh water is, of course, a well established process which has been widely used, especially on board ship where it is not always an economic practice to take up valuable space with the supplies of fresh water needed for drinking purposes and for the ship's boilers. The process is not without its difficulties, however, and it is to find ways of overcoming these difficulties that much research in evaporation is at present directed. A major difficulty arises from the fact that sea water contains large quantities of various substances in solution. As evaporation proceeds, the concentration of these substances in the water are increased, until a point is reached at which they begin to be deposited as a scale on the heating surfaces and elsewhere in the evaporator. Scale is also formed by the decomposition of bicarbonates as the water is heated. This scaling progressively reduces the effectiveness of the evaporator and, with the types commonly used in which the sea water is passed through a number of steam-heated tubes, some or all of these tubes

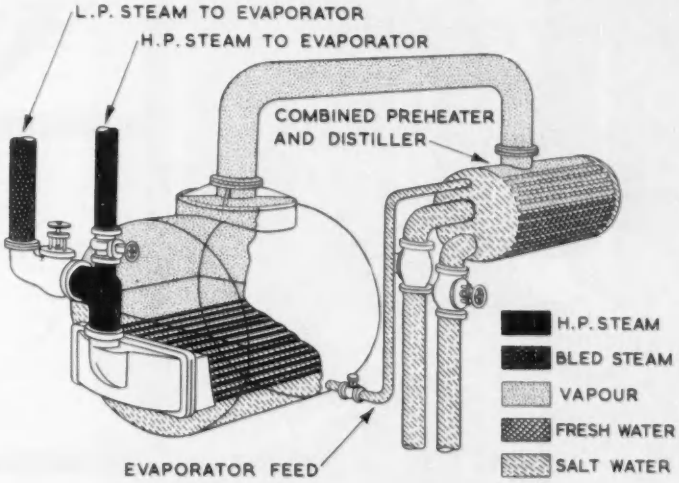
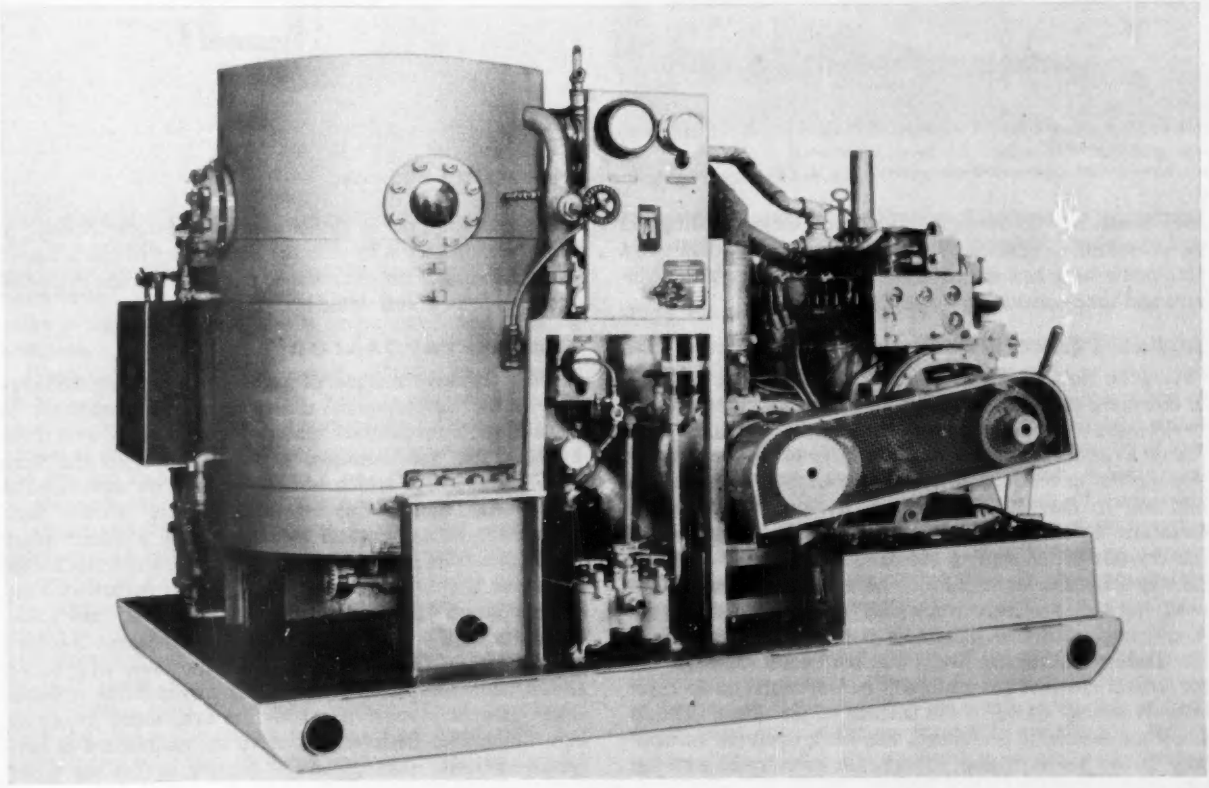


FIG. 2 (*right*). Diagrammatic arrangement of a low-pressure evaporating and distilling plant.

FIG. 3 (*below*). A hundred-gallon-an-hour diesel-drive (positive-displacement) compression still made by the Badger Manufacturing Company of Cambridge, Mass., U.S.A.



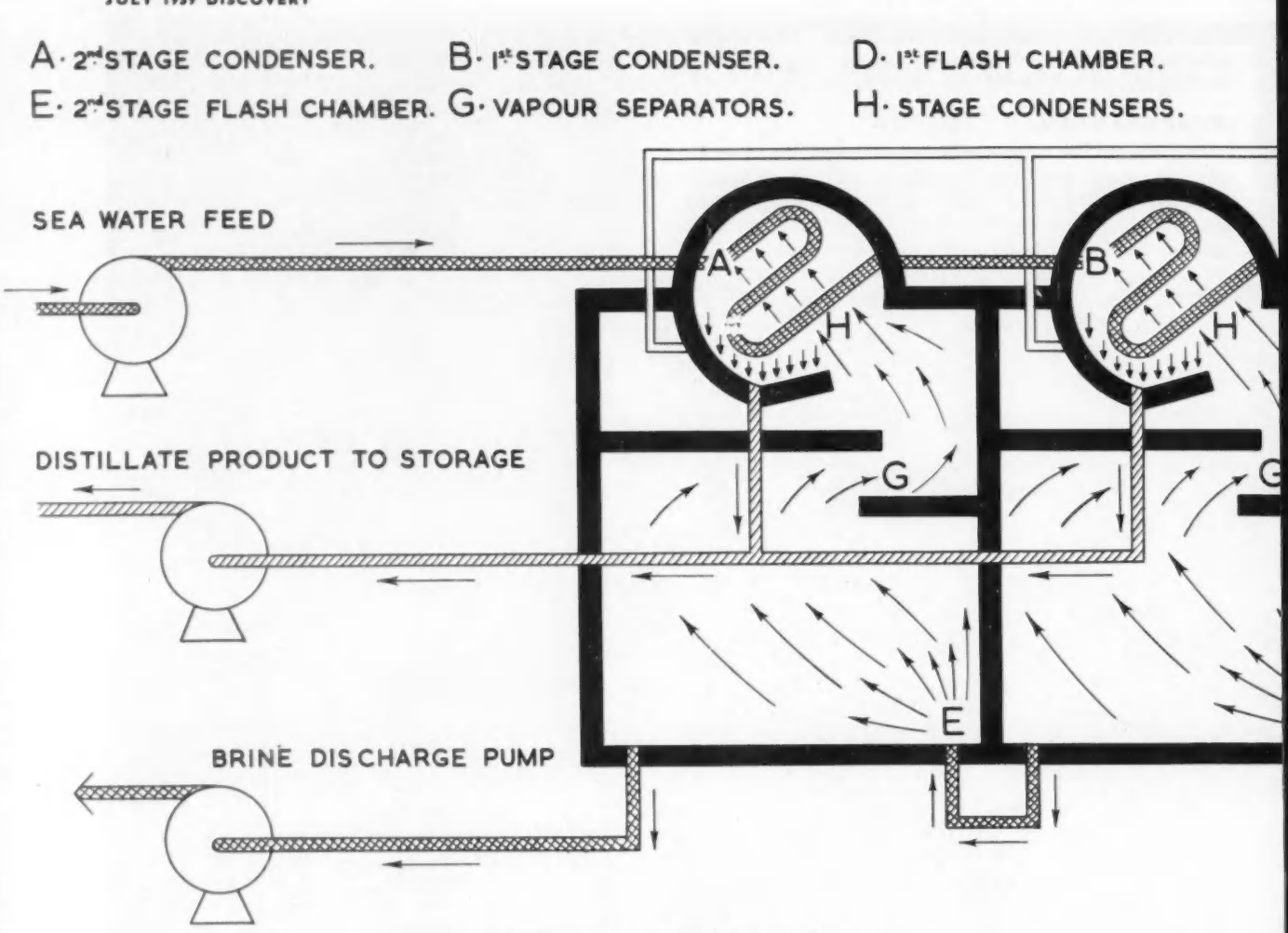


FIG. 4. Diagram showing the principles of a flash evaporator.

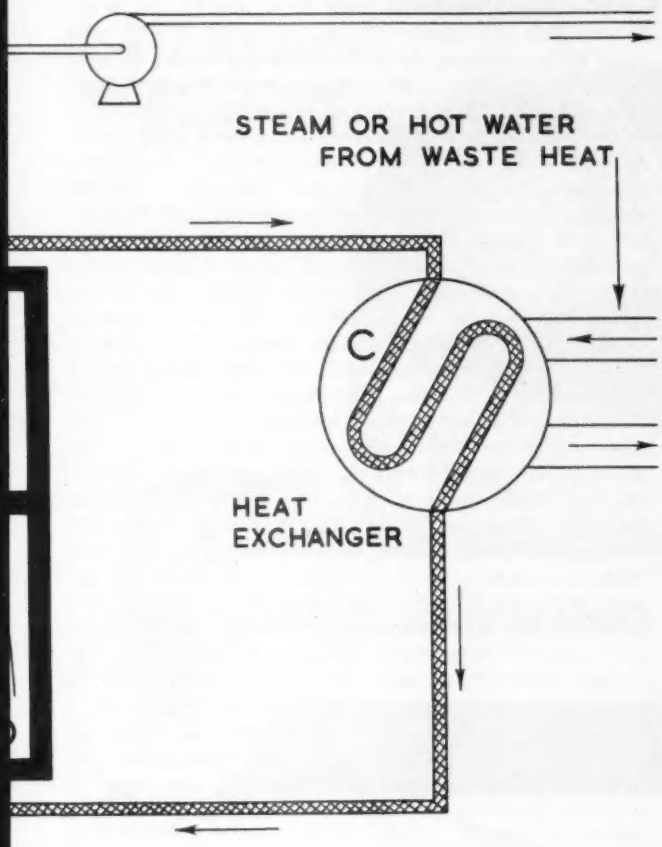
may eventually be completely blocked. Unless scaling can be prevented in some way, therefore, the evaporator must frequently be taken out of service for cleaning—an expensive and time-consuming operation.

SCALE PREVENTION

A good deal of research on scale prevention, which is a common problem in the evaporation of other liquids besides sea water, is at present in progress, and there is no reason to doubt that satisfactory techniques will be evolved. Among the techniques now being developed is that of the addition to the sea water of small amounts of organic materials which interfere in some way with the growth of the crystals of the scaling substances. Inorganic additives such as acids and ferric chloride have also been successfully used, but they are corrosive, which may be a disadvantage. A different method of approach is to circulate crystals of the scaling substances with the sea water through the evaporator, so that the scale will be deposited on to these crystals instead of on to the surface of the tubes. This is a method which, it is claimed, has been operated successfully in the Soviet Union, though not specifically with sea water evaporators. A rather similar technique devised in the United States is to pass the sea water through a bed of sand external to the evaporator; the scale is then deposited on to the sand grains in the bed.

FLASH EVAPORATOR

An alternative method of avoiding the scaling difficulty lies in the development of new types of evaporator to replace the conventional tubular type. Scaling difficulties are avoided, for example, in what is called the flash evaporator, a type which is being extensively developed at the present time. The essential feature of the flash evaporator in its simplest form is merely a vessel maintained at a suitably reduced pressure, into which the heated sea water is sprayed. Here the water boils instantaneously and the steam "flashes" off and if scaling does take place, it occurs in the flash vessel, where it does not interfere seriously with the operation of the evaporator. In practice, although the simple single stage flash evaporator is sometimes used, it is more usual for the evaporator to consist of a number of flash vessels in series, maintained at progressively lower pressures. The heating of the sea water



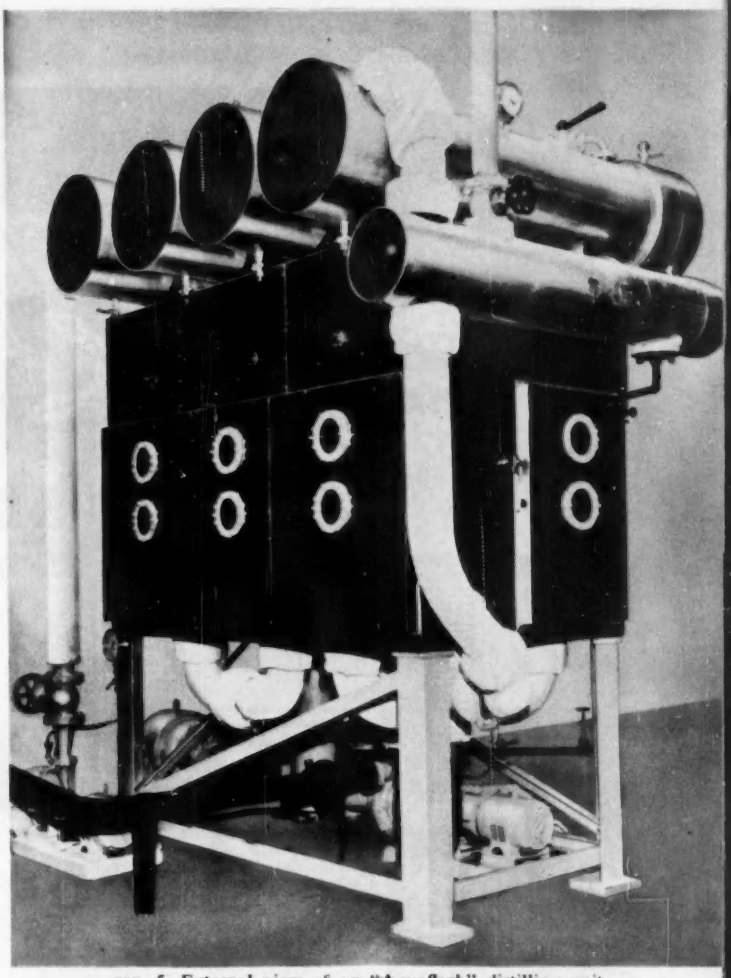


FIG. 5. External view of an "Aquaflash" distilling unit.
(Photograph by courtesy of Buckley and Taylor)

takes place in a completely separate part of the unit from the flash vessels. The heaters used are tubular, but scaling is avoided in this part of the system both by keeping the temperature to which the sea water is heated below the value at which scaling would be encountered, and by using additives.

Flash evaporation is particularly adapted to the use of cheap supplies of warm water, such as are provided, for example, by the waste cooling water from oil refineries and chemical plants, or by the comparatively warm water of the surface layers of the ocean. At the same time, the steam produced can, before it is condensed, be used to drive a turbine and thus provide power. A pilot flash evaporator plant of this type has been operated successfully at the University of California. A far more ambitious project is that proposed for Abidjan in the French Ivory Coast. This would make use of warm surface sea-water, which would be evaporated, while the steam produced would be used to produce power and then condensed by means of colder water drawn from the ocean depths. The experimental trials for this scheme were completed in April 1956, but Government approval to put it into operation has so far not been obtained. An indication of the scale of this project is given by the fact that the completed plant would produce about 7000 tons of fresh water per day.

THERMO-COMPRESSION

Evaporation is a process which is inherently costly in energy, since it involves the separation of large quantities of water, as vapour, from comparatively small quantities of dissolved solids. For this reason it is most often used where supplies of cheap fuel are available, as the source of this energy, for example in the vicinity of oil fields or oil refineries. For the same reason, methods of conserving energy are of great importance in the design of evaporation plant. One of these methods is that known as vapour recompression or thermo-compression. In this process, the vapour evolved from the boiling sea water in the evaporator is not condensed, but is compressed. As a result of the compression, the energy content of the vapour is increased sufficiently for it to be returned to the evaporator to serve as the heating medium. Thus the continued supply of fresh steam from outside the evaporator is not needed, though some energy is, of course, required to drive the compressor.

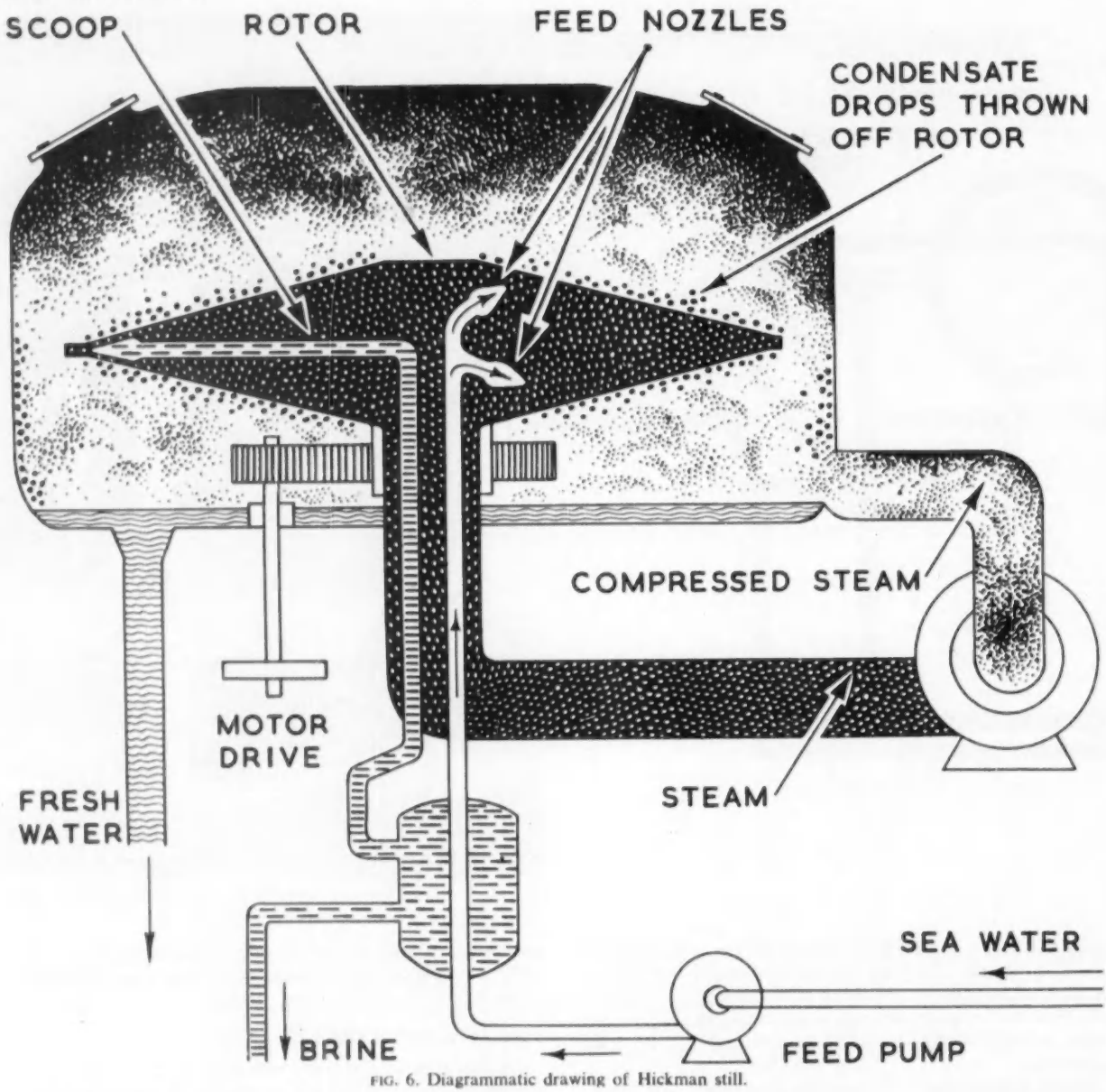


FIG. 6. Diagrammatic drawing of Hickman still.

After being used to heat the sea water, the compressed steam condenses to give the supply of fresh water required.

A new type of vapour recompression evaporator, called after its inventor, the Hickman still, is now being developed. This evaporator is also non-tubular in construction. Instead of being passed through steam-heated tubes, the sea water is fed into the inside of a rotating unit which, in one of the types so far tested, took the shape of two cones placed base to base. The rotation of the unit spreads the sea water out into a thin film, thus markedly increasing the rate of heating. The steam formed is withdrawn from the rotor, compressed, and then fed back to the outside of the rotor to serve as the heating medium. Here it condenses, and the droplets of water are flung off the rotor and are collected. Because the sea water is made to assume the form of a thin film, the evaporator can be operated with only a comparatively small difference in temperature between the steam and the sea water. The amount of energy which must be supplied to the steam is therefore reduced, with a consequent reduction in the size and cost of the compressor. At the same time, it is claimed that the shear forces set up in the film of sea water by the rotation of the unit tend to prevent the formation of scale on the surface of the rotor. Because of the numerous advantages which the Hickman still appears to possess, the results of further trials and the development of a full-scale plant are awaited with interest.

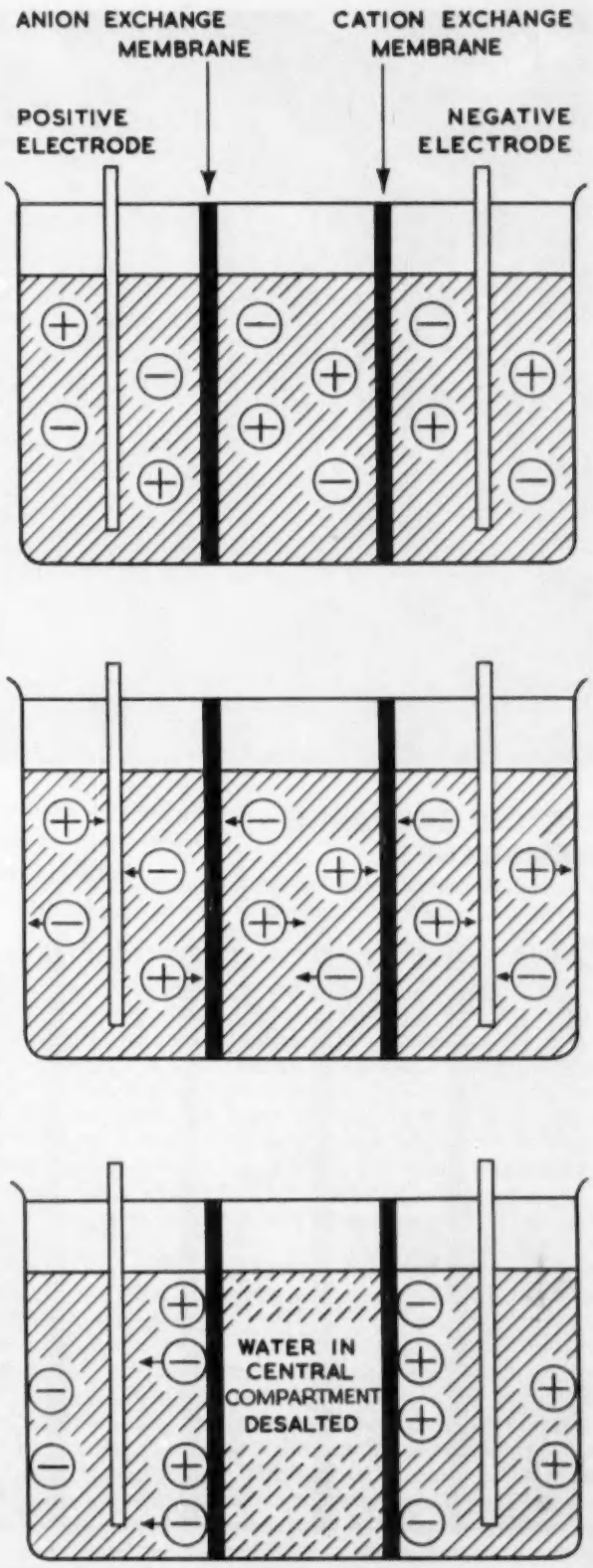
ELECTRODIALYSIS

In electrodialysis, in contrast to evaporation, the dissolved solids are removed from the water; this is achieved

by taking advantage of their electrical properties. The salts in salt water, in fact, are present in the form of negatively and positively charged particles called ions. Thus, common salt is present in water as positively charged sodium ions together with negatively charged chloride ions. By applying an electrical potential across a vessel containing salt in solution in water, the ions can be made to migrate; the positive sodium ions will move towards the negative electrode (the cathode) and the negative chloride ions towards the positive electrode (the anode). With this arrangement, however, there will be no resultant desalting of the water, since in any given vertical slice of the water, as many ions, on average, will move into it as leave it. It is necessary, therefore, to divide the vessel up by means of special membranes made of ion-exchange resins. In the simplest form of electrodialysis unit, the vessel is divided into three compartments by means of two such membranes, one of which allows only positive ions (cations) to pass through it, and the other only negative ions (anions). The membranes are arranged in such a way that, when the potential is applied, both cations and anions are withdrawn from the central compartment, passing through the cation- and anion-exchange membranes to the cathode and anode respectively. At the same time, however, the membranes prevent other ions moving into the central compartment to take the place of those which have been withdrawn. Thus the water in the central compartment is effectively desalted.

In practice, an electrodialysis plant may consist of a "stack" of as many as 300 membranes. In an American plant of this type, for example, two such stacks are operated in series and are capable of handling a flow of 28,000 gallons of brackish water per day with an overall reduction of 64% of the salt content. This is sufficient to convert a brackish water into a water of salt content low enough for use as drinking water, or for irrigation purposes. In this country, an electrodialysis plant with an output of about 2000 gallons per day has been built for the Libyan Public Development and Stabilisation Agency, to be installed at Tobruk. Largest of all the plants so far is that under construction in South Africa and intended to handle about a quarter of a million gallons of salt water per day. This is water which is pumped out of the gold mines in the Orange Free State and which is too salty merely to be discharged into the River Vaal. At the same time, fresh water needed by the mines has to be pumped from the river over a distance of 40 to 50 miles. It is hoped that ultimately it will be possible to treat by electrodialysis the entire output of salt water from these mines, amounting to some 2½ million gallons per day.

Electrodialysis is still a comparatively new process and its economics have yet to be fully worked out. The ion-exchange membranes are usually expensive and cannot be used indefinitely. The cost of replacing membranes thus forms a high proportion of the total running costs of the process, and this cannot at present be estimated with any certainty. One of the important contributions made by the South Africans has been to develop cheap membranes; these are produced by impregnating Kraft parchment with the necessary organic chemicals. In addition, these membranes, which were expected to have a life of about three months, now appear to be lasting for as long as nine months before replacement is needed.



FIGS. 7–9. Electrodialysis.

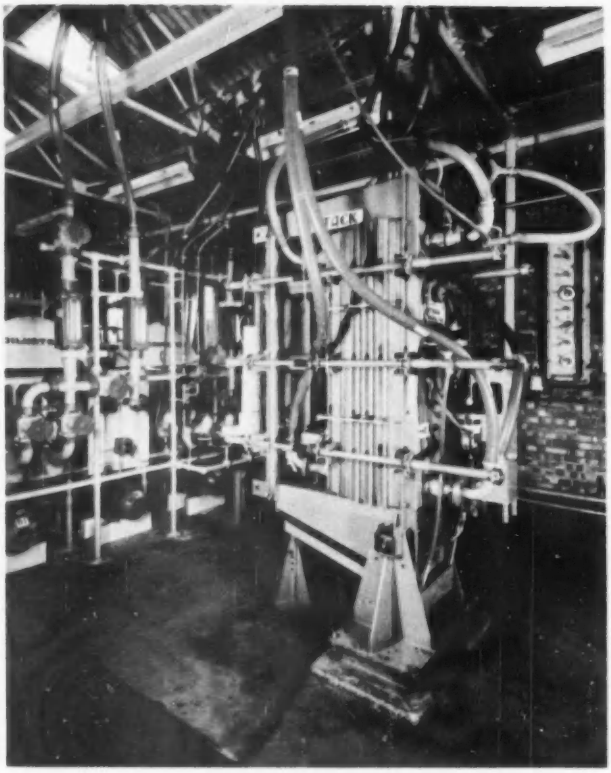


FIG. 10 (*above, left*). Electrodialysis desalting plant made by William Boby of Rickmansworth, England; this unit was shipped to Tobruk.

THE OSMIONIC PROCESS

Although evaporation and electrodialysis are the two processes of saline water conversion which have been developed furthest at the present time, other techniques are also being investigated. Somewhat resembling electrodialysis is the so-called osmionic process which has been developed by Murphy at the State University of New York. An osmionic unit consists of a vessel divided into four compartments by means of four ion-exchange membranes, two of the cation-exchange type and the others of the anion-exchange type. One of the compartments contains a concentrated salt solution, while the two compartments adjacent to it contain salt solutions of lower concentration. The remaining compartment contains the water to be desalted. The unit is so arranged that, because of the difference in concentration, anions leave the concentrated solution to enter one of the adjacent compartments containing the less concentrated solution, while the cations pass into the second of the adjacent compartments. If this process were to continue, electric charges would build up in the compartments adjacent to that containing the concentrated salt solution. Electrical neutrality is preserved, however, by the passage of ions of the appropriate charge out of the fourth compartment, that is, the one containing the water to be desalted. The desalting of this water is thus effected without the need for any external supply of energy. No practical details of the operation of this ingenious system are so far available.

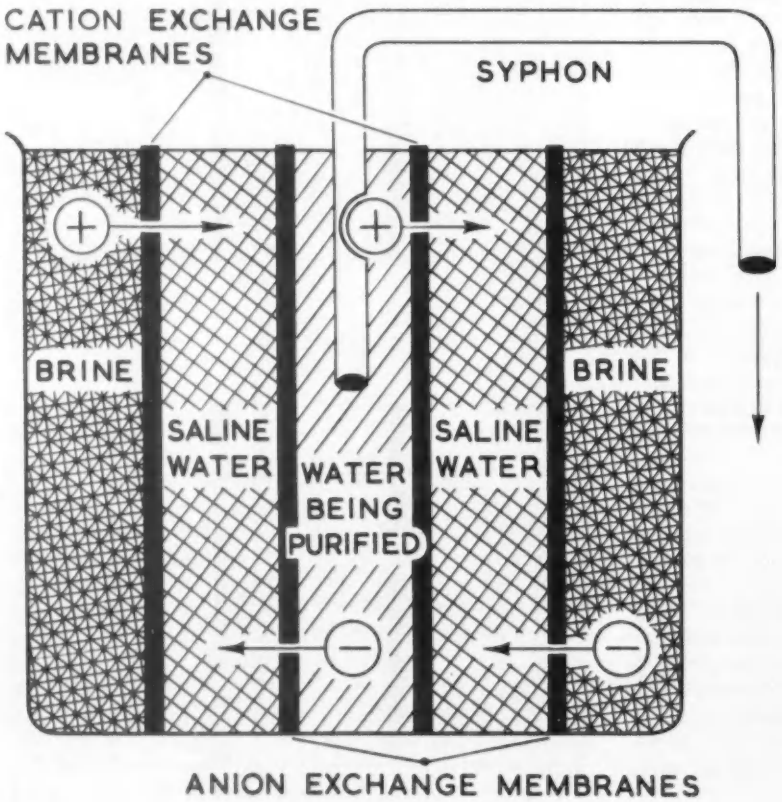


FIG. 11 (*left*). Simple osmionic cell. (*Redrawn from* Ind. Eng. Chem., *August, 1958*)

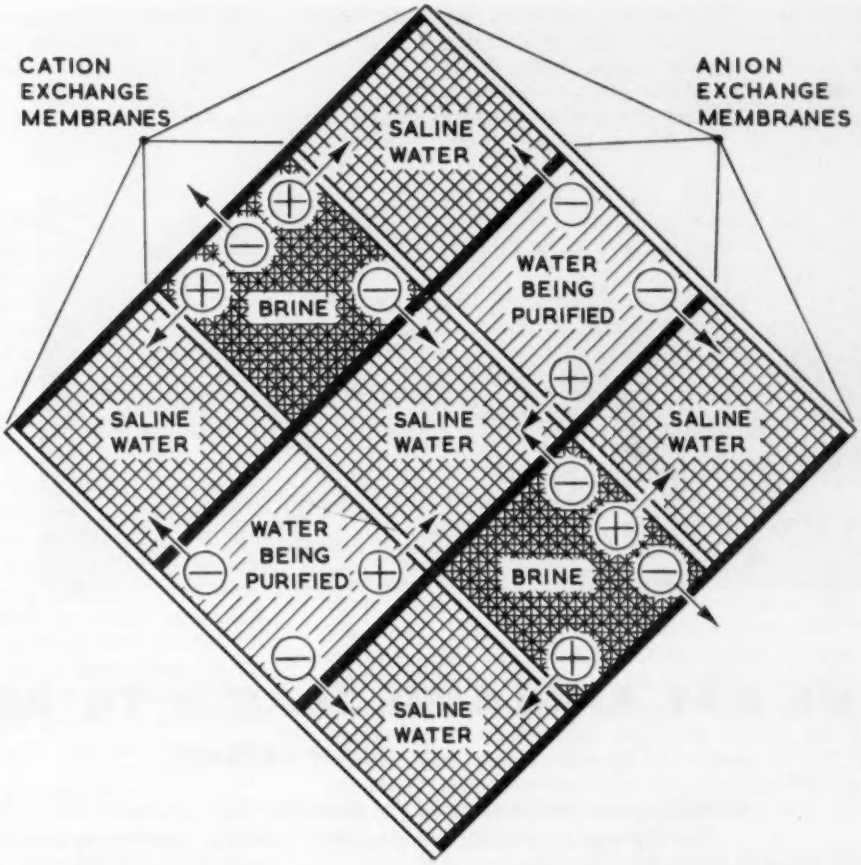


FIG. 12. Honeycomb type of osmionic cell.
(*Redrawn from* Ind. Eng. Chem., *August, 1958*)

This type of cell has the advantage, as compared with the simple osmionic cell, of giving the shortest possible distance for the ions to travel, for a given membrane separation. It thus makes the best use of the available energy in the system, so that the membrane area required is reduced to the minimum. The membranes provide their own spacer and supports, and therefore need not be so thick as in the simple type, with a corresponding saving in cost. When the membranes expand or shrink, as a result of wetting or drying, the whole assembly does likewise, so that difficulties associated with dimensional changes would probably be avoided. The construction of large cells of this type cheaply still presents formidable problems, though a kind of non-working mock-up has already been built.

FREEZING, SOLVENT EXTRACTION AND OTHER PROCESSES

Freezing provides an alternative means of producing fresh water from salt water. When salt water is frozen, the ice formed is free of dissolved substances, which remain in the water from which the ice has crystallised out, the "mother liquor", as it is called. It is difficult to produce pure ice in block form, however, since large amounts of mother liquor tend to become enclosed in the blocks and to adhere to the surfaces. One possible way of overcoming this difficulty is to allow the ice to form as a mass of fine crystals in which no mother liquor can be enclosed. The liquid adhering to the surface of the crystals still has to be removed, however, by filtration or centrifugation. Alternatively, in a process which has been tried out in France, part of the ice is allowed to melt and to carry away with it the adherent mother liquor.

At Texas Agricultural and Mechanical College, work is in progress on the solvent extraction of sea water. With a suitable organic solvent, of which over 200 have been tested, the water dissolves in the organic liquid, in which, however, the salts are insoluble. By heating, the water can be freed from its solution in the organic liquid and separated. The solvent is then available for treating a further quantity of sea water. Large amounts of a probably expensive solvent would be required if this process were operated on a big scale.

Among other processes investigated is the development of special membranes consisting of two fritted clay ceramic plates separated by a very thin layer of oil; this is taking place at the University of California. It appears that it has been possible to desalt water by forcing it under high pressure through such membranes. Desalting has also been effected by means of a process originating from Sweden in which the sea water is subjected to a pressure of 280 atmospheres at the same time as it is heated to a temperature of 475°C. In this "critical" region, the sea water separates into two layers, the upper of which contains only a very small proportion of the original salt content. Both these methods involve the use of high pressure and would therefore probably be expensive to operate.

Many other schemes have been proposed. It has even been suggested, for example, that advantage could be taken of the fact that certain living organisms are capable of extracting salts from water and concentrating them in their body fluids. It would probably be necessary to employ a whole series of such organisms in this biological growth method, since the range of external salinity which can be tolerated by any one organism is usually small. While such schemes as this are obviously remote from any practical application, there is no doubt that the difficulties of saline water conversion will ultimately be overcome. The speed with which success will finally be achieved might perhaps be increased if the importance of adequate supplies of fresh water for the world as a whole was more widely realised.

FIG. 1. Blériot flying over the Channel. (It is just possible that this photograph might be a fake and is not the Blériot Mark XI.)

THE DAY ENGLAND CEASED TO BE AN ISLAND

EGON LARSEN

Only fifty years ago the idea of flying across the English Channel was considered ridiculous. This feat was accomplished by a crippled man in a rickety aeroplane on July 25, 1909

"Why does not Lord Northcliffe offer a prize for a flight to the moon? It would be just as likely to be won," wrote a London newspaper when its rival, the *Daily Mail*, offered £1000 for the first flight across the English Channel. It seemed, indeed, a ridiculous venture in 1909; less than six years earlier, the Wright brothers had managed to get their heavier-than-air machine off the ground for twelve seconds for the first time.

Hubert Latham, an Oxford-educated young man of twenty-six, son of a French mother and an English father, was determined to win the prize. He had won his first trophy after only five flying lessons. His Antoinette monoplane, with a V-8 engine built by Levavasseur and a graceful, boat-shaped fuselage, had made many fine flights. Latham moved it to Sangatte, near Calais, where he housed it in a shed previously used for the abandoned project of digging the Channel Tunnel. He announced early in July his intention of attempting the flight, and started his trials.

The Antoinette engine made a deafening noise, but even that was often drowned by the din of the daily disputes between Latham and his bearded engineer—mainly because the airman was readier to risk his life than was the engineer to risk their precious machine.

Latham's first attempt ended in a French cornfield. The second, on July 19, 1909, took him a few miles out to sea; then the engine failed, and Latham fell into the water. A French destroyer found the wreck and the airman on it, smoking a cigarette, his feet propped up out of the water. He was given a hero's welcome when he arrived back in Calais, and smothered with kisses. But more than ever before people on both sides of the Channel were convinced that the venture was to remain suicidal for many years to come; perhaps for ever.

Another competitor had arrived at the French Channel coast. His name was Louis Blériot, a well-to-do lamp manufacturer in his middle thirties, who had been badly bitten by the "flying bug" when he saw Clément Ader's steam-powered aircraft (which, of course, never flew) at the Paris Exhibition of 1900. Blériot collaborated with Voisin in experiments with a machine that was towed on floats, and designed his first monoplane in 1907. His great achievement as a designer was the development of a new means of maintaining lateral stability; the Wright brothers had invented the system of "warping" the wings, but Blériot used for the first time small subsidiary movable planes, or ailerons, hinged to the edges of the wings, to keep his machine steady in the air.

His monoplane of 1907, nicknamed *canard* by his friends, was wrecked only four days after its first flight. His second machine had two pairs of wings, one behind the other; it flew less than 200 yds. before dropping like a piece of lead. His third, with an elevator and rudder at the rear, crashed after a flight of 500 yds. Blériot climbed out, smiling. He had set up a record: three machines wrecked in eight months.

The year 1908 brought him no better luck. One machine

after another crashed without serious injury to the intrepid airman, still less discouragement—although he had spent something like £30,000 on his hobby. The longest distance he covered was 25 miles, but a week later the machine burst into flames in mid-air. Blériot was pulled out of the wreckage with a severely burnt foot. It was his fiftieth flying accident.

THE FLYING WHEELCHAIR

"When, on the morning of July 21st, 1909, my husband set off from Paris for Calais, he certainly had no idea of the glory that awaited him [said Mme Blériot in her reminiscences]. The machine, Blériot XI, was at last ready near Calais. My husband was compelled to rest as he was suffering from his badly burnt ankle."

It was not, however, much of a "rest"; he was determined to win Lord Northcliffe's prize.

"The Blériot XI was about half the size of Latham's machine [a friend recalled]. With its wings folded up it needed little more space than an automobile. It was towed from Calais behind a horse and cart. The first time I saw it uncovered, Blériot's mechanics were working on it, hemmed in on all sides by a large, interested crowd. In the foreground, on a chair borrowed from a nearby cottage, sat a man of about thirty-seven with a heavy moustache, apparently a cripple, directing operations by waving his crutch and pointing it to various parts of the machine. To my astonishment, the cripple turned out to be Monsieur Blériot. He greeted me with the words, 'I cannot walk, but I can fly!' "

The Bleriot XI was a comparatively elegant monoplane with the engine slung under the wing and the pilot's seat above it; the tailplane with the elevator and the vertical rudder was large. The wing span was 25 ft. 6 in., and the total supporting surface of 150 sq. ft. was loaded at about 4 lb./sq. ft. An air-cooled Anzani engine of 22–25 h.p. drove a two-bladed tractor airscrew directly; it was started by swinging the wooden propeller by hand. This engine had never run for more than twenty minutes without getting overheated.

For three days Blériot had to wait for favourable weather. He was extremely impatient, thinking and talking of nothing else but his cross-Channel flight. In the evenings at his hotel he used to cover the tablecloth with drawings of future aeroplane types he wanted to build.

"Shortly after 2.30 a.m. on the morning of July 25th [related Blériot's friend], I was roused by the hotel porter. A little over an hour later I was down at the beach listening to the running of Blériot's engine. It was not yet light, but Blériot began a trial flight at 4 a.m. He covered about 9 miles. The air was clear; there was only a suspicion of a breeze.

"When he returned to his starting-point he announced that he was ready. 'You can't start yet,' said his mechanic. 'Remember the conditions of the contest. The flight across the Channel must be made between sunrise and sunset. It is now 4.15; sunrise is not till 4.30.' The mechanic held his watch in his hand and I talked to Blériot while the minutes ticked by. With a close-fitting cap pulled down over his forehead and ears and his big moustache more prominent than ever, I could not help thinking how much he looked like a walrus. He said that his engine had never run better. He was absolutely certain of his success. His last remark was, 'See you at Dover!'

"At 4.35 the mechanic gave the signal. Blériot hobbled to the machine, dropped his crutch, and climbed in, his

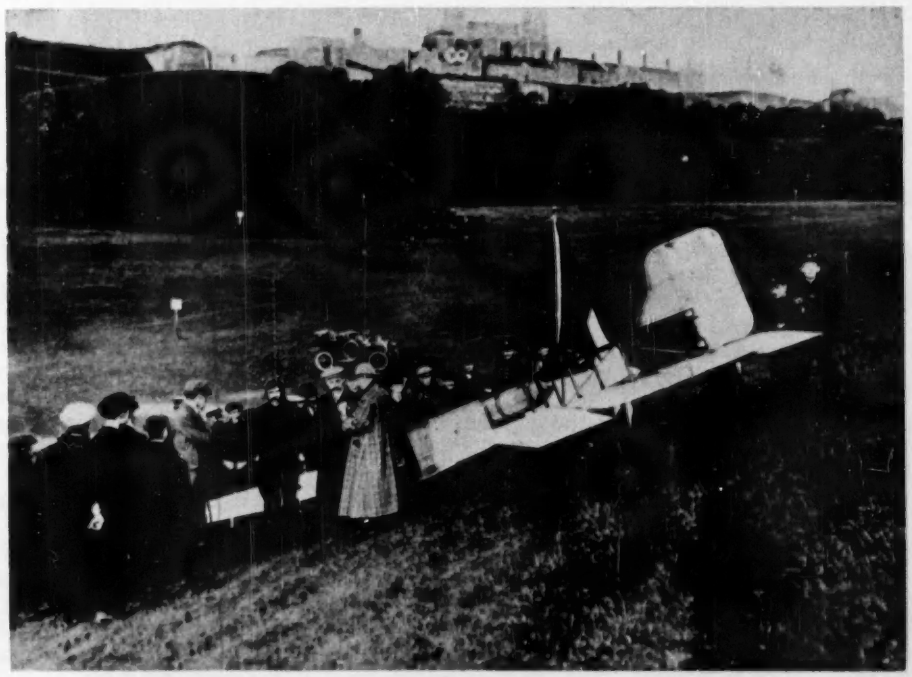


FIG. 2. Blériot (in flying outfit) after arriving at Dover on July 25, 1909.
The Blériot Mark XI plane had a wooden frame and was covered with waterproof linen. Span, 25 ft. 6 in.; length, 26 ft. 3 in.; weight, 496 lb.; wing area, 150 sq. ft.; air-cooled Anzani 3-cylinder engine of 20 h.p., capable of over 40 m.p.h. The flight of 24 miles was covered in about half an hour.

FIG. 3. Blériot sitting in his machine, with Anzani, the constructor.
(Photographs by courtesy of Radio Times, *Hulton Picture Library)*

injured foot in a slipper. About fifty or sixty people in various stages of undress had assembled to see the start. It was such a crowd as one might see at an early-morning fire. Even now I can recall a man who, having hurriedly put on his trousers and shirt and forgotten his braces, was reduced to holding up his trousers with one hand while waving the other and shouting, 'Long live Blériot! Vive la France!' "

"THAT FLYING MAN IS HERE!"

Hubert Latham was still fast asleep in his hotel bed when the Blériot XI rose from the beach at Barraques, skimmed the telephone wires, flew over the cliff edge, and headed out to sea. Friends of Latham's ran to his hotel; but it was too late to get the damaged Antoinette ready. Still, there was more than a chance that Blériot would fail.

In fact, he was only half-way across the Channel when the engine began to knock: the pistons and cylinders were getting uncomfortably hot. Surprisingly, it picked up its former rhythm again; a slight rain had helped to cool it down. The danger point seemed to have passed.

Mme Blériot had been allowed on board a French destroyer with a small number of reporters.

> "I scoured the sky and sea with my glasses [she said later]. Anxiety increased the more we approached Dover. We knew nothing of what was happening. Imagine, then, the joy that seized us when a member of the crew who had exchanged signals with the shore told us that Blériot had landed safe and sound!"

He had come down, with not a soul about to witness the event, on Northfall Meadow after a 24-mile flight of half an hour. Then two Frenchmen who had been waiting for him appeared, and next—most appropriately—an English policeman. He ran to the nearest telephone and rang his station to report, "That flying man is here!" The time was 5.12.

Blériot was taken to London, where he was given a royal reception. But in his hour of triumph he did not forget his unlucky rival, and offered to share the £1000 prize with him if Latham, too, would cross the Channel that day. However, the weather had freshened, the Antoinette was not quite ship-shape again, and Latham had to give up. For the first time he had tears in his eyes.

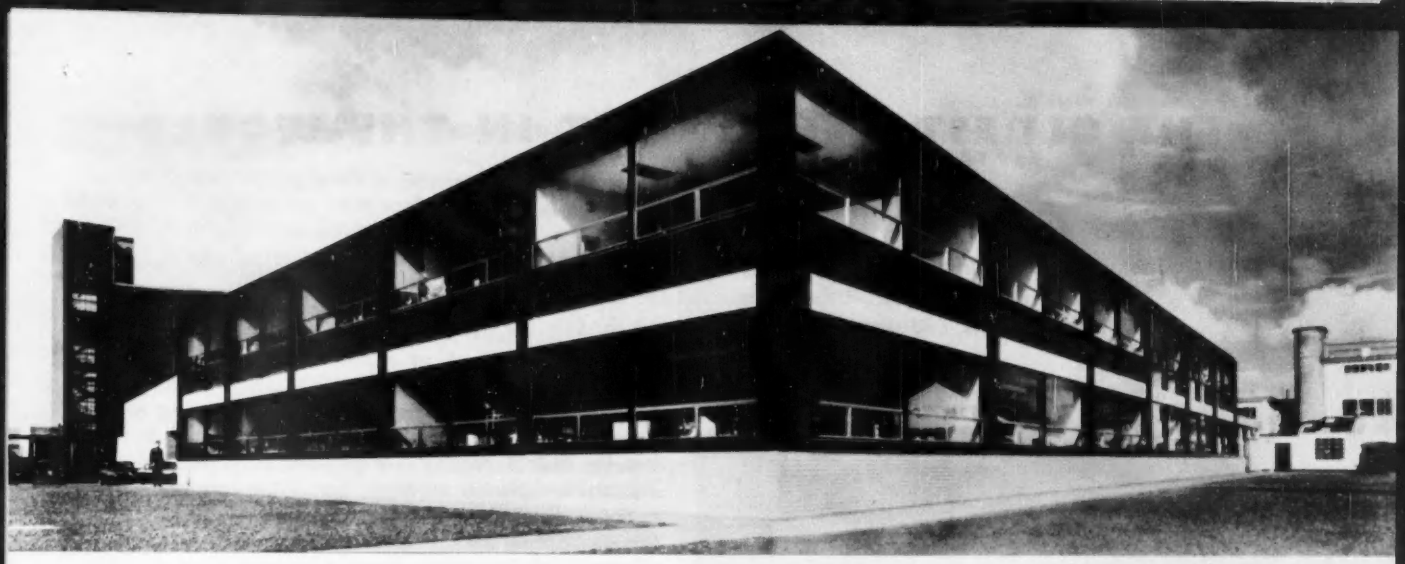
It was a tremendous victory for Louis Blériot personally and for the aeroplane as a means of transport. But Lord Northcliffe himself had little doubt about the significance of the event; he suggested as the main theme of the *Daily Mail* report: "England has ceased to be an island". The next day, the *Daily News* said in its leader:

> "A rather sinister significance will, no doubt, be found in the presence of our great Fleet at Dover just at the very moment when, for the first time, a flying man passed over that 'silver streak' and flitted far above the mast of the greatest battleship. Of course, such an event suggests all manner of fresh dangers as well as fresh advantages for the future, and it is one more evidence of some absurdity inherent in our civilisation that our first thought about aeroplanes would be their possible use in war."

To this the Secretary of State for War replied that the War Office could see no use in encouraging flying which would be quite useless for military purposes. That was five years before the first aeroplanes appeared over the battlefields of France.

Blériot remained in the flying business for a while. He believed in it "as a means of bringing mankind and nations closer together, not as an instrument of death and destruction". Yet the aircraft factory which he opened, and which turned out about 800 machines of forty different designs up to 1914, accepted a contract to build military aeroplanes for the British Royal Flying Corps after the outbreak of the war.

He died peacefully in his bed at the age of sixty-four in 1936. Hubert Latham, who had crashed within a mile of Dover when he made another cross-Channel attempt two days after Blériot, became one of the earliest "stunt pilots". He always boasted, however, that he would never die in an air accident. He was right. He was killed while big-game shooting in Africa, gored by a wounded buffalo.



AESTHETICS OF SCIENTIFIC BUILDINGS

The trend in many modern building programmes is to follow simple aesthetic lines and make as much use of natural light as possible, by means of large sheet-glass windows. The photographs on this page are of three new buildings of CIBA (ARL) Ltd, manufacturers of resins, which are good examples of this style of architecture.

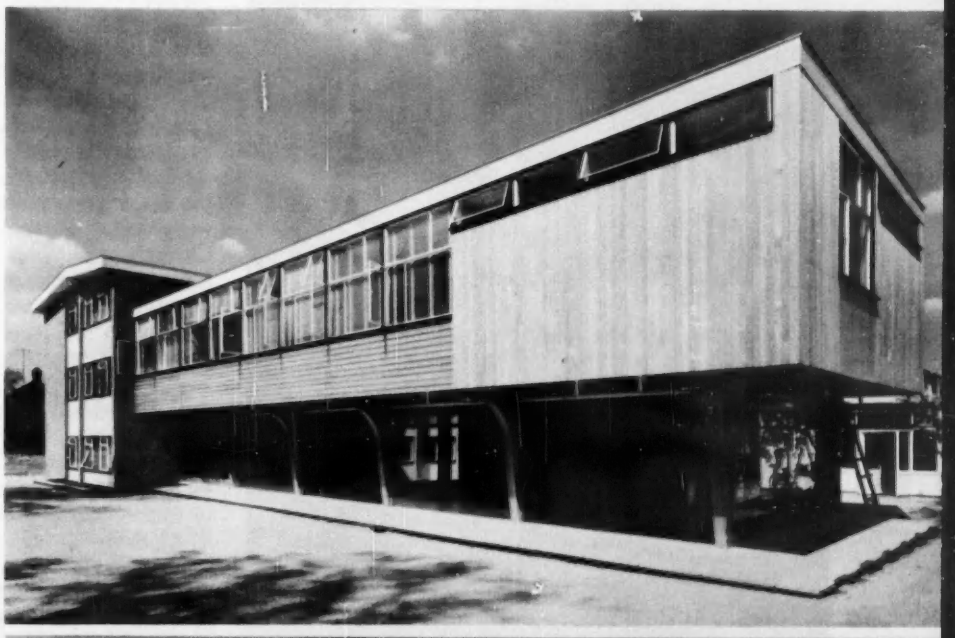


FIG. 1 (*above*) is an L-shaped laboratory of pre-cast and *in situ* concrete construction and brick. The walls mainly consist of panels of polished plate-glass. Internally, artificial lighting is diffused by honeycomb panels and heating is provided by hot water radiant panels in the ceiling. There is a duct system throughout the building which provides fresh air and extracts fumes.

FIG. 2 shows a display and office block The display section on the ground floor has walls almost entirely made of sheet-glass. The second floor is supported on portal frames which add to the symmetry of the whole building.

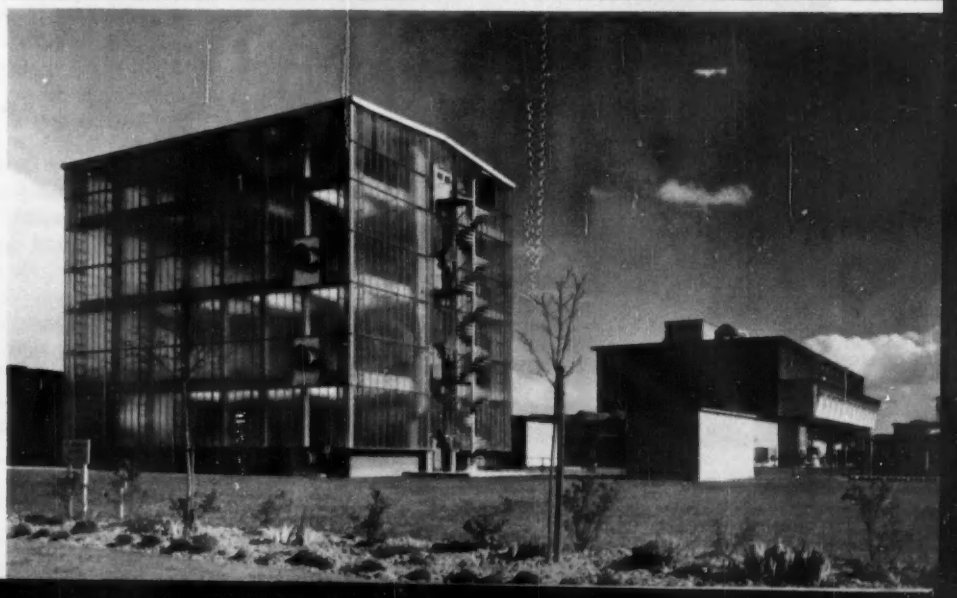


FIG. 3 is an illustration of a modern factory building. Built of concrete it is clad almost throughout with glazed curtain walling. The ventilation system on the left wall provides five changes of air per hour. This can be geared up so the air is changed thirty times an hour. The fire escape on the right balances the very severe lines of the building. It is interesting to see that all three buildings have flat roofs.

THE OLDEST EXPERIMENT IN THE WORLD

H. V. GARNER, O.B.E., M.A.
Rothamsted Experimental Station, Harpenden

The inheritance of an estate at Rothamsted led to the establishment of Broadbalk, the first experimental farm in England. It was here that the treatment of soil and the cultivation of crops were first put on a scientific basis, and research has continued now for over one hundred years.

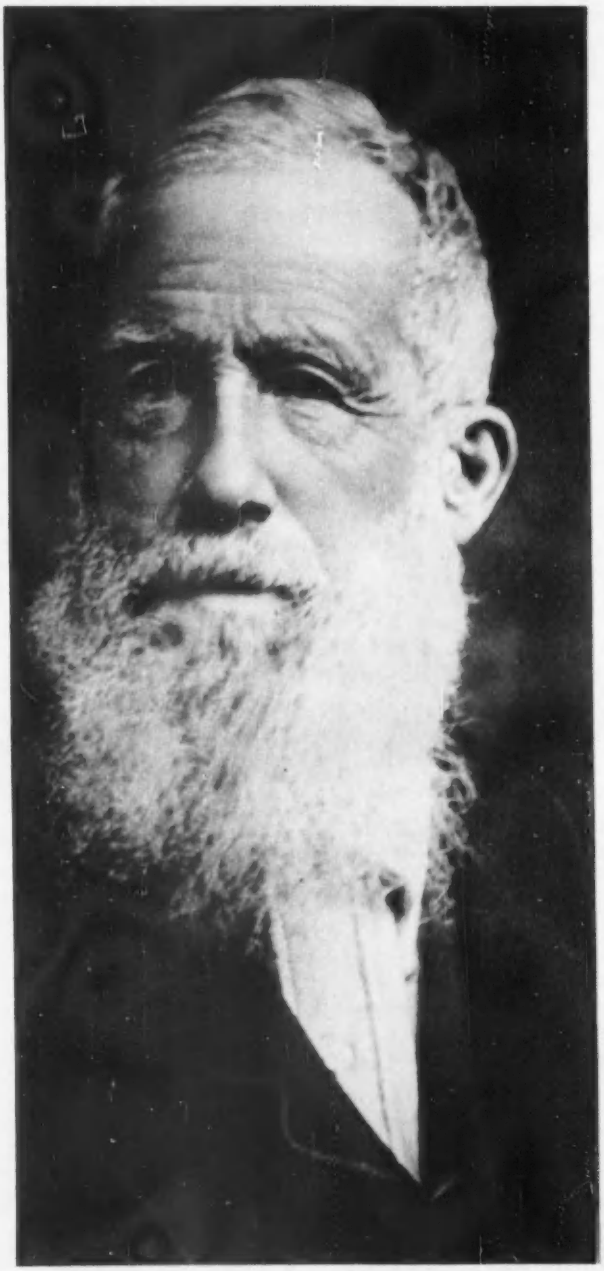


FIG. 1. Sir John Bennett Lawes (1814–1900), founder of the Rothamsted Experimental Station, 1843.

When the young squire of Rothamsted started a field experiment on wheat in 1843, he little thought that it would last for over a century and provide, even today, unique material for scientific work.

The background of this remarkable achievement lay in the qualities of the man himself and the peculiar circumstances of his time. John Bennett Lawes had many advantages, a keen and original mind, great energy, the countryman's sure feeling for the land, and sufficient resources to put his schemes into operation.

Although the "hungry forties" were times of great hardship both in England and still more so in Ireland, this period saw the beginning of an agricultural revival after the long depression that followed the Napoleonic wars. Landowners were again interested in improvements: under its motto "Practice with Science" the *Journal of the Royal Agricultural Society*, which started in 1840, gave an outlet for the most progressive sections of the industry. There was keen interest in soil fertility and higher output. Chemists and plant physiologists had begun to express plant growth in scientific terms, and the subject had been clarified and summarised by Prof. Justus von Liebig of Giessen in his report to the British Association published as "Chemistry in its Application to Agriculture and Physiology".

The short list of manures: bones, soot, rape cake and the like, was just beginning to lengthen. Nitrate of soda and guano were coming in, people were starting to use the crude liquor from the gasworks and the large-scale manufacture of ammonium salts was in sight. The testing of these and other materials was obviously necessary and a start had already been made by the newly founded agricultural societies, using rather crude methods. More scientifically, the versatile French chemist, J. B. Boussingault, had already begun experiments on his farm at Bechelbron in Alsace; some of these measured uptake of nutrients as well as crude yields.

CHEMISTRY AND AGRICULTURE

While he was at Oxford Lawes attended lectures in chemistry by Dr Daubeny who, in addition to holding the Chairs of Chemistry and Botany, was also the first Professor of Rural Economy. Daubeny was interested in plant nutrition and had done microplot experiments in the old Botanic Garden. He was a friend of Liebig and, strangely enough, was invited by the British Association to present a paper on the connexion between chemistry and agriculture in the very year that Liebig prepared his famous report for another section of the same body. With Liebig's book in his hand, Daubeny decided to use his material elsewhere. Although young Lawes was probably influenced by his

professor, his chemical interest first turned towards drugs rather than agriculture.

Lawes started farming when he inherited the Rothamsted estate in 1834 and he was soon confronted with a practical problem: bones, at that time, almost the only source of phosphorus for crops in addition to farmyard manure, were very uncertain in their action; on some soils they increased yields but not on others. By tests, first in pots and soon afterwards in the field, Lawes found that bones treated with sulphuric acid, as recommended by Liebig, were much more effective, and in 1842 he took out a patent for treating bone products and rock phosphate with acid to make superphosphate.

By that time Lawes had gone far enough with his experiments to see that there was likely to be a considerable demand for this quick-acting source of phosphate, and he set out to make a long-term study of the new manuring, not merely, or even chiefly, manuring with phosphate but manuring in its widest sense.

In spring 1843 his plans had reached a stage where he needed a scientific assistant, and he engaged a young chemist, J. H. Gilbert, who, though not primarily interested in agriculture, had spent some time in Liebig's laboratory at Giessen. The first experimental wheat crop was sown in the following autumn. The field chosen was eleven acres of very old arable land consisting of clay-with-flints resting on the chalk at a depth of about 15–20 ft. The land lay on a slight slope and would ordinarily be described as clay loam although surveyors recognise three distinct soil series within its boundaries. Under the customary rotation such land produced about twenty-four bushels of wheat per acre, rather less than the English average at that period. It had previously carried four corn crops without manure and was therefore in a low enough state of fertility to measure fertiliser effects. The plan was simple but effective, twenty long narrow strips laid side by side sampled the whole length of the field. Each received a different manurial treatment which was repeated year after year for an unbroken succession of wheat crops. This continuous system brought its own agricultural problems, but it excluded the uncertainties arising out of the residual effects of diversified cropping. Probably for this reason it was also adopted for most of the other long-term experiments laid down by Lawes and Gilbert. A feature of Broadbalk which turned out to be of the greatest value was the size of the individual plots; at half an acre each they were big enough to appeal to visiting farmers, but, more important, even after many years they were little affected by the mixing of soils at the boundaries of adjacent treatments. Moreover with some 150 tons of topsoil per plot the ever-increasing demand for soils for scientific work can still be met without harming the experiment.

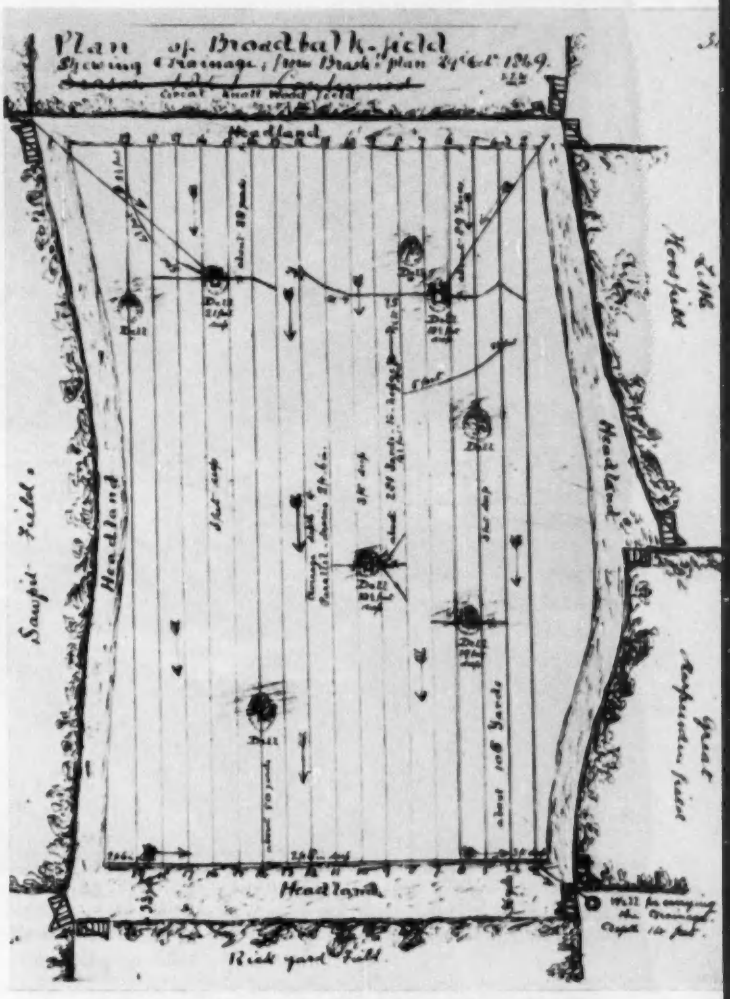


FIG. 2. Sketch plan of Broadbalk field, 1849. The position of the land drains, one in the centre of each of the seventeen long strips into which the field is divided, can be seen. The dells are pits from which subsoil chalk was dug and spread many years before the experiment started. The wide headland or "baulk" at the bottom of the field probably gave the field its name.

FERTILISER AND SOIL STUDIES

From the outset the main purpose of the experiment was to find out whether the ash constituents of plants applied as simple salts containing phosphorus, potassium, sodium, and magnesium, could produce satisfactory crops, as maintained by Liebig, or whether direct additions of nitrogen compounds were also needed. It was very soon established that the ash constituents alone produced very little more wheat than completely unmanured land, whereas when these were supplemented by ammonium salts yields were increased. These preliminary findings were put on record in the *Journal of the Royal Agricultural Society* after harvesting the third experimental crop. It now remained to devise a set of treatments that could be used to analyse these main effects further, and in 1852 the manuring of Broadbalk fell into what turned out to be its permanent form. There was soon a rich harvest of agricultural information which gained in reliability as time went on. The small effect of the ash constituents on land depleted in nitrogen was confirmed. The shape of the response to increasing dressings of nitrogenous manure was determined. Nitrogen used alone, effective in the first few years, began to fail as the soil supply of minerals was depleted. The effect of the various components of the mineral mixture were disentangled and potash stood out as more useful than sodium or magnesium. Other forms of combined nitrogen,

FIG. 3. The Testimonial Laboratory (1855–1914), built for Lawes by public subscription (previously Gilbert's chemical work was done in an old barn on the farm). The gallery was used to store the vast number of samples of soil and crops from Broadbalk and the other classical fields.

such as sodium nitrate and rape dust, were compared with ammonium salts. Ammonium salts, unlike minerals, had almost no residual effect after one crop had been grown. Under the conditions prevailing on Broadbalk yearly dressings of a complete inorganic fertiliser, containing a generous amount of nitrogen, gave as much wheat as large yearly dressings of farmyard manure. This list could be greatly extended but a firm basis for the manuring of wheat was clearly emerging and much of the information had much wider applications.

Much more than the crude yields were studied; Gilbert's laboratory was an essential part of the scheme from the beginning. Systematic analyses of the Broadbalk soils, manures, drainage, and crops were made to determine the uptake of nutrients and lay the necessary foundations to find soil changes from different treatments applied over many years.

One early chemical investigation that had far-reaching practical consequences was the analysis of the drainage from individual plots. Six years after the experiment started the plots were tile-drained for purely practical reasons, but in 1866 the drains were opened up at the bottom of the field so that the runnings could be collected separately. From 1866 onwards many analyses were made by A. Voelcker and later by Frankland. Very little phosphorus was found in the drainage, and soil analysis showed that most of the phosphorus not taken up by the crops was also still present in the surface soil. Potassium was slightly more mobile than phosphorus but for most practical purposes could be regarded as held in the root range of crops. Nitrogen and calcium appeared in quantity in the drainage, and although Broadbalk had sufficient reserves of calcium carbonate to stand the annual loss for many years, the loss of nitrogen (which at that time was applied in the autumn) was much more serious. The remedy as Lawes and Gilbert showed lay in the timing of the nitrogen dressings. As new analytical methods were introduced, Broadbalk soils and crops often provided unique test material. Thus towards the close of last century there were Dyer's determinations of available phosphorus and potassium in soils by his citric acid method. In this connexion it is interesting to note that Liebig himself had determined phosphorus, potassium, and other bases in dilute acid extracts of Broadbalk soils as early as 1872. In the twenties of this century interest centred on the determination of exchangeable bases. More recently there have been spectrographic determinations of potassium and other bases in the produce and minor element studies in soils and crops.

CROP STATISTICS

The long series of measured yields on the Broadbalk plots provided R. A. Fisher, then first head of the Rothamsted Statistics Department, invaluable material for statistical research on crop variation. His first paper published in 1921 showed that the grain yields from the different plots had three types of variation: annual variation caused partly by weather; steady deterioration of the soil; and slow changes caused in part by weed infestations. The annual deterioration in yield was calculated for each treatment. It was small for the dung plot and for the plot receiving a heavy dressing of nitrogen supported by phosphorus and potassium, but larger for plots that were incompletely manured. In a later paper, Fisher used the long period meteorological observations made at Rothamsted to study the effect of rainfall on wheat, and he calculated the average effect of an inch of rain at all times of the year. Differently manured plots responded differently to rainfall. In general, the Rothamsted rainfall was in excess of the requirements of wheat. Rainfall in excess of the average was harmful at any time of the year, except in October on certain plots, and particularly harmful in winter on plots receiving nitrogenous fertiliser. Fisher's methods were subsequently applied by his co-workers to the yields of other long-term experiments, sometimes with less successful results, but the statistical techniques that were developed in the course of these investigations have since come into use throughout the whole of biological research.

The main agricultural problem in continuous corn-growing is weeds, and the log book of the experiment is full of references to this trouble. Great efforts were made to keep the field clean by hoeing and hand weeding, but in wet years even this was unsuccessful. When labour became increasingly scarce and expensive, the only practicable alternative was to introduce periodical bare fallows. This was started in 1925 and made a definite break with the time-honoured system. Regrettable as these changes are, this particular one has enriched the experiment in several ways and opened up new scientific investigations. In 1952 a small area of the field was taken out of the fallow cycle and returned to continuous wheat to see whether modern herbicides can accomplish what hand labour failed to do.

Much botanical work has been done on the weed flora of Broadbalk. In the early days it was chiefly surveys of the distribution of species, but the introduction of the regular bare fallow led to a full-scale sampling investigation to find the number of viable seeds of each species before and after fallowing and their speed of recolonisation. Some of the numbers were enormous. Poppy, for example, one of the worst weeds before the fallow, had 113 million living seeds per acre. Other work measured the period of dormancy of many species when subjected to ideal conditions of germination in pans. Some waited as long as ten years before they sprouted. A further result of continuous cropping is the build-up of diseases and pests. The rigid system of cropping and manuring practised on Broadbalk presented pathologists with a unique opportunity of studying seasonal relationships, and the effects of different plant nutrients on the incidence of disease. For the past twenty-five years the fungus disease commonly known as Eyespot (*Cercosporella herpotrichoides*) has been intensively studied on Broadbalk by Dr M. D. Glynne. The old experimental records describe symptoms that were almost certainly those of the disease but it was first recognised in Britain on this field in 1935. Since then a vast amount of quantitative information on seasonal and cultivation relationships has been recorded yearly. Apart from season, the chief beneficial effect comes from the full year's clean cultivation during bare fallowing, which considerably reduces the damage to the next wheat crop, though the disease soon builds up again in subsequent crops.

Comparable information has been collected on take-all disease (*Ophiobolus graminis*), which was found to be very much decreased by bare fallowing, and was also partially controlled by nitrogenous manuring.

Another relationship between nutrition and incidence of

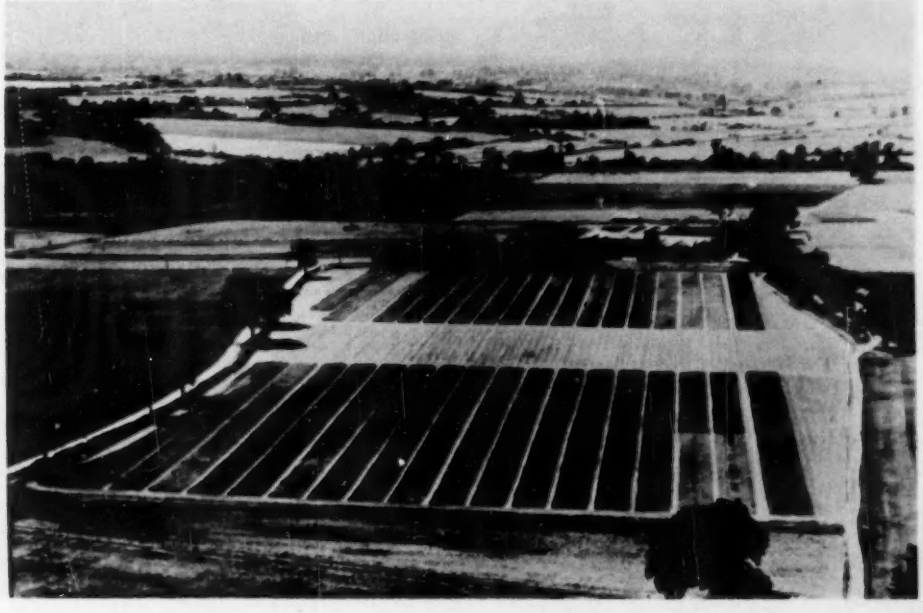


FIG. 4. Broadbalk Field, June 1950. The centre section across the field is being bare fallowed. The next section nearer the foreground carries the first crop after the fallow of 1949. The section nearest the foreground has the second crop after a fallow in 1948. The two strips on the right receive dung and no manure respectively. The striking first-year effect of fallow on the unmanured land is clearly shown.

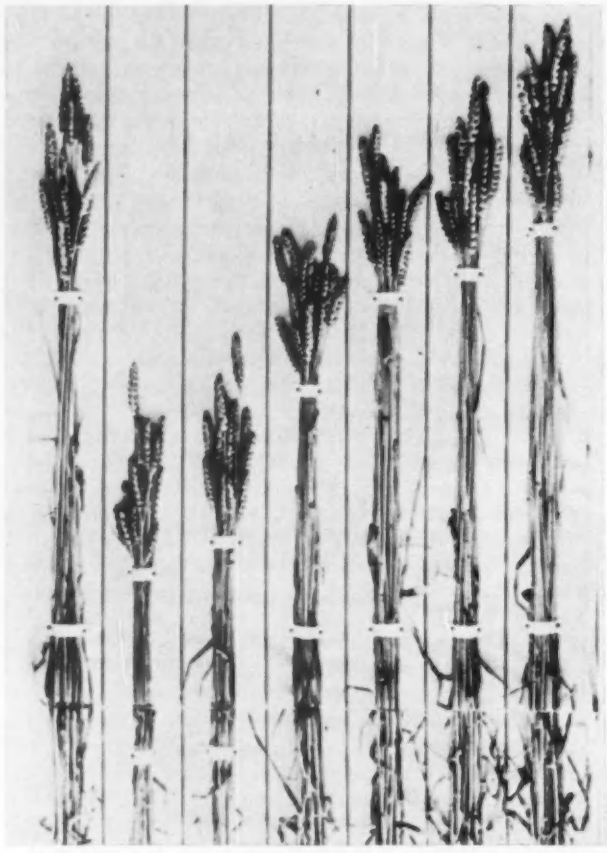
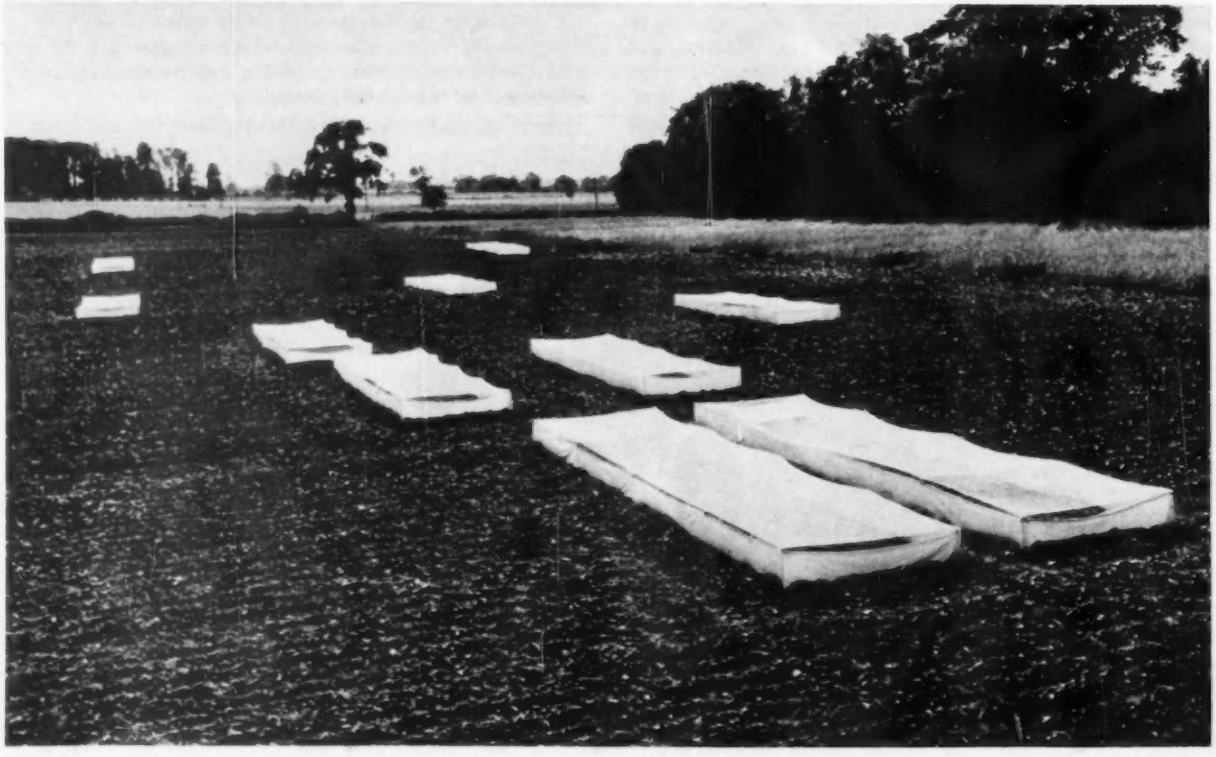


FIG. 5 (*left*). Sample plants taken in 1943 from the plots of the 100th year of the experiment. Manures applied yearly for every crop: from left to right: dung; nil; "mineral manures", i.e. P, K, Na, Mg, without N; minerals with single ammonium sulphate; minerals with double ammonium sulphate; minerals with treble ammonium sulphate; minerals with double sodium nitrate.

FIG. 6 (*below*). The fallow section of Broadbalk being used for an entomological investigation. The covers are to prevent the wheat bulb fly from laying eggs in the bare soil in summer. The wheat on these areas and neighbouring areas exposed to egg-laying will be weighed in the following year to measure the loss of crop due to the larvae of the wheat bulb fly.



fungus disease has recently been observed on Broadbalk, where mildew (*Erysiphe graminis*) was most severe on plots without potash.

ZOOLOGICAL SURVEYS

Zoologists have used the Broadbalk plots for numerous surveys and population studies. The first was in 1922 when a detailed comparison of the numbers and species of invertebrates was made between the highly fertile organic soil of the dunged plot and the completely unmanured land low in nutrients and organic matter alongside. The dunged land, with about 15 million invertebrates per acre, had three times the population of the control.

Five years later H. F. Barnes began his classical long-period observations of two species of wheat blossom midge, *Contarinia tritici* and *Sitodiplosis mosellana*. Broadbalk with its fixed cropping-system provided an established population of midges and their parasites and predators suitable for studying seasonal effects. Data on number of larvae attacking the wheat, number of midges and their parasites emerging each year, and dates of emergence of midges and parasites have been collected yearly since 1927.

With the introduction of the bare fallowing cycle, Broadbalk provided each year a section of the field where the wheat followed one year's fallow, a sequence particularly favourable for the wheat bulb fly (*Leptohylemyia coarctata*). The serious damage by this pest in the Eastern Counties in 1953 stimulated research and part of this was naturally done on Broadbalk, where the effects of extremes of nutrition and cultivation could be studied. Larval infestations in spring and effects on grain yields have been measured annually.

Fallowing increases yield so strikingly on Broadbalk, particularly on plots low in nitrogen, that it has been suggested that part of the response may reflect the activity of nitrogen-fixing organisms during the fallow period. Azotobacter and Clostridium have been frequently counted by Dr J. Meiklejohn on a selection of plots, and Azotobacter cells are most plentiful on plots that give the biggest response to fallow, that is, those low in nitrogen. This organism shows a peak population in spring in the year after fallow. Clostridium is much more numerous that Azotobacter. Broadbalk still remains a rich source of material for scientific work; some of the investigations mentioned above may branch out in other directions, and whenever a modification in management is made new possibilities present themselves. Thus the recent liming of some of the plots, amply justified on agricultural grounds, has thrown up some interesting problems on the relationship of the incidence of take-all disease to the previous treatment of the plots.

In the course of its long history, Broadbalk has mirrored the development of agricultural methods and formed a background to a number of personalities. Most of this lighter material has come, not from the formal log-books of the experiment, which apart from graphic descriptions of the ever-present weed trouble are terse and impersonal, but from the reminiscences of Edwin Grey, who came to Rothamsted as a boy in 1872 and was employed on the experiments till 1922, in his later years as field superintendent. For nearly thirty years he worked under Lawes and Gilbert and thoroughly imbibed the atmosphere of the old régime. With an excellent memory and a fine journalistic sense, Grey recorded the day-to-day operations on Broadbalk in its middle period. It is clear from his writings that the Broadbalk of 1872 was managed in much the same way as in its earliest days.

BROADBALK MECHANISED

Oxen were still to be seen at plough on Broadbalk in the 'seventies; in the early period superphosphate was actually made on the farm and the manures were mixed and applied by hand with elaborate precautions to prevent them drifting on the wind from one plot to the next. Labour was plentiful and the wheat was hand-hoed by gangs of men, and weeds hand-pulled by schoolchildren; the plots were cut and tied by hand, sometimes by large gangs of casual labourers sufficient to harvest the whole 11 acres in a day; teams of schoolboys then gleaned the plots by hand, the loose straws being carted home with the rest. At all stages a responsible supervisor was present, who could expect a visit from Dr Gilbert or even from the founder himself when any important operation was in progress.

The binder was used on the plots for the first time in 1901, the horse-rake took the place of the gleaners, and soon afterwards the manures were put on by drill. Heavy cultivations began to be done by tractor in 1919. There was then no important change in technique for nearly forty years when the combine harvester replaced the binder and threshing machine.

As a demonstration of the first principles of soil fertility, Broadbalk has no equal. Every plot has some relevant contribution to make to the general picture. Four generations of visitors have walked round the plots—a first-hand demonstration by the men who had nursed the experiment into its final form must have been a great experience. With improved communications both at home and abroad the influence of this classical experiment has widened. Nearly all the 3000 scientists and farmers who come to Rothamsted each year pay a visit to these plots; many of them make as close a study of Broadbalk in all its aspects as time permits. This exercise is almost part of the curriculum of students from our university department and agricultural colleges.

After all, Lawes and Gilbert added a new dimension to the agriculture of the 19th century; their first signpost is still there for everyone to see.

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DUBNA—RUSSIA'S ATOMIC CITY

D. DANIEL

This Russian equivalent of CERN was built for research on the peaceful uses of nuclear energy. Some exciting discoveries have been made in Dubna's laboratories.

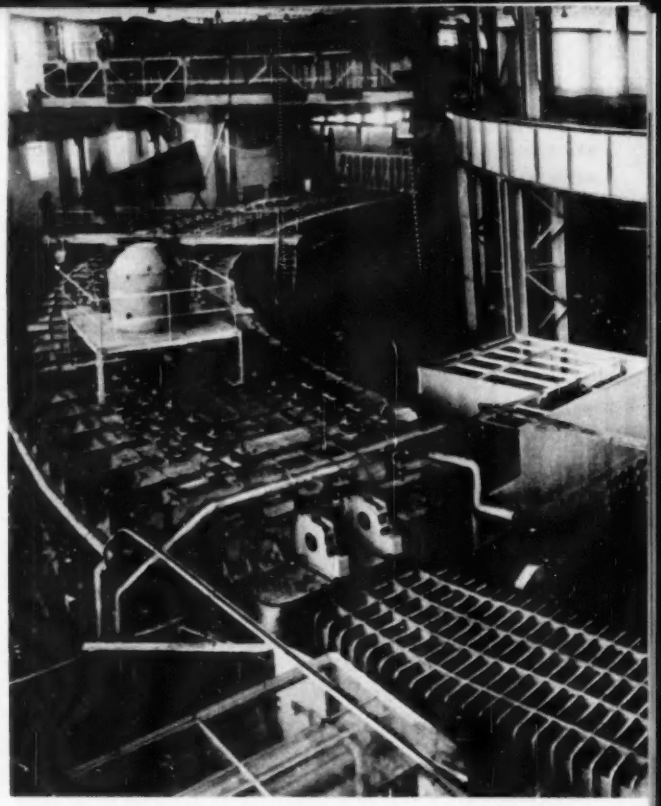


FIG. 1. A general view of the proton synchrotron of 10,000 million electron-volts in the Electrophysical Laboratory of the Academy of Sciences in Russia.

The international communist Nuclear Research Institute at Dubna, on the Volga, has been expanding rapidly since Russia set it up three years ago, and Soviet scientists have made important contributions to the advancement of nuclear physics in that period.

The Institute, composed of scientists from the twelve member States of the Soviet bloc, is situated in a specially built Atomic City, 95 miles north-east of Moscow. The site was once a village; now more than 7000 people live there. Nearly all of them are connected with the Institute, though most have been doing constructional and service work.

The Joint Nuclear Research Institute, to give it its exact title, is Russia's answer to the European Organisation for Nuclear Research, which was formed five years ago also by twelve countries, including Britain, to co-operate in basic research into high-energy nuclear physics. The EONR, generally known as CERN from the initials of its official French name—Conseil Européen pour la Recherche Nucléaire—is situated in the Swiss village of Meyrin, near Geneva.

The Dubna Institute employs about 2000 people, including some 300 scientists, mostly Russian. Of this total about 50 come from the other Communist States—Albania, Bulgaria, China, Czechoslovakia, East Germany, Hungary, Mongolia, North Korea, North Vietnam, Poland, and Rumania.

Communist Yugoslavia is not represented at Dubna; she is a founder member of CERN, together with Belgium, Britain, Denmark, France, West Germany, Greece, Italy, the Netherlands, Norway, Sweden, and Switzerland.

Both centres are pledged to study only the peaceful uses of nuclear energy.

ADMINISTRATION AND FINANCE

To set Dubna on its feet, the Soviet Union gave the Institute an initial 500 million roubles' (about £45 million at the official rate of exchange) worth of equipment. This included the world's most powerful atomic accelerator, the 10,000 million electron-volt proton synchrotron. Since then many more millions of roubles have been spent on new equipment, laboratories, and buildings. The exact amount is a secret, but the evidence of Western scientists who have visited Dubna is that the supply of money for research appears unlimited.

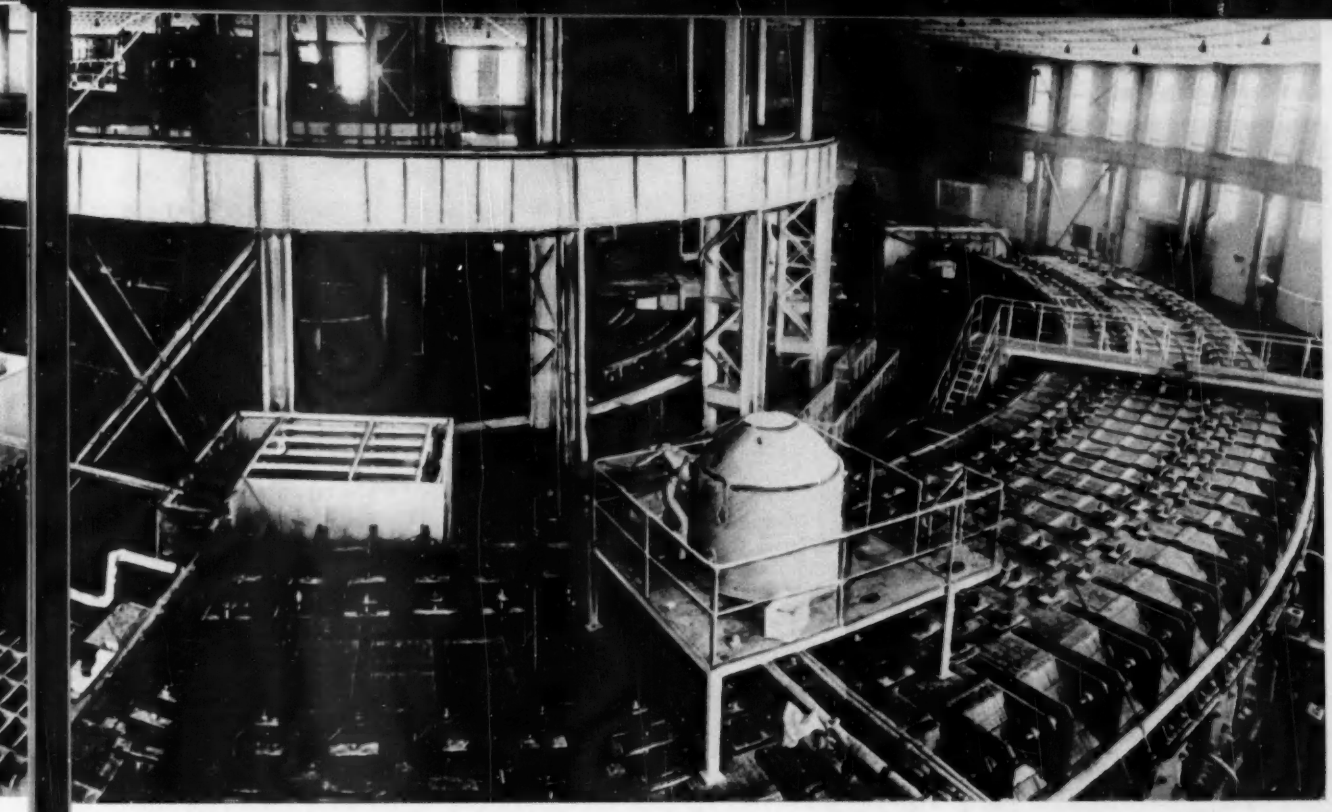
Russia spends huge sums on science. The current Soviet national budget calls for an expenditure of 723,369 million roubles (£64,585 million), of which 27,300 million roubles (£2,500 million), about 4%, is for scientific purposes.

The cost of running Dubna is shared between the twelve members. Russia pays 47·25%, China 20%, Poland and East Germany 6·75%, Czechoslovakia and Rumania 5·75%, Hungary 4%, Bulgaria 3·6%, and the other four countries the balance between them.

The centre was set up by an agreement signed in Moscow on March 26, 1956, which emphasised the great importance of the peaceful uses of atomic energy for the good of all mankind. It recognised the necessity for co-operation between scientists of different countries in theoretical and experimental nuclear physics research to advance this cause.

The agreement provides for a director to be elected for a term of three years and for two deputy directors for two-year terms. Dr Dmitry Blokhintsev, corresponding member of the Ukraine Academy of Sciences, the first director of the Institute, was recently re-elected for another three-year term. The two deputy directors are Prof. Wang Kang-chang of China and Prof. Emil Dzhakov of Bulgaria. These two succeeded Prof. Vaclav Votruba of Czechoslovakia and Prof. Marian Danys of Poland.

A scientific council was set up to discuss and approve research plans, results of research, and other questions arising from the Institute's work. Council members are



appointed by the scientists of the member States, each State selecting not more than three people.

The council, which has thirty-two members at present, meets twice a year to consider the centre's achievements. It held its last session between January 14 and 17 this year, when it approved plans for further extensive research in the Institute's five laboratories in 1959.

There is also a financial committee, with each State represented by one member and the chairmanship rotating among all.

HUGE PARTICLE ACCELERATORS

Like CERN, Dubna is built round two huge particle accelerators, though at CERN only one of the accelerators is operating so far—the 600 million electron-volt proton synchrotron. The second, a far more powerful machine, the 25,000 million electron-volt proton synchrotron, will be finished next year.

The agreement establishing the Dubna centre laid down that it should consist of the following research organisations:

1. A Laboratory of Nuclear Problems with a proton synchrocyclotron with proton energy of 680 million electron-volts. This was handed over to the Institute by the former Nuclear Problems Institute of the Soviet Academy of Sciences.

2. A High-Energy Physics Laboratory with a proton synchrotron with planned proton energy of 10,000 million electron-volts.

This was in the former Electro-Physics Laboratory of the Soviet Academy of Sciences and was handed over to the Institute with all related equipment and installations when Dubna formally began operations on September 28, 1956.

The agreements also authorised the building of the following installations:

(*a*) A Laboratory of Theoretical Physics with computing department and electronic computing machinery.

(*b*) A Laboratory of Neutron Physics with an experimental nuclear reactor with a high density of neutron stream.

(*c*) A Cyclotron for accelerating the multi-charged ions of various elements and for experiments with them in the Nuclear Problems Laboratory.

The head of the High-Energy Physics Laboratory is Prof. Vladimir I. Veksler, corresponding member of the Soviet Academy of Sciences. Reporting to the second Geneva "Atoms for Peace" Conference last September on the operation of the bigger of the two principal accelerators, Prof. Veksler said that the particles which make up the atomic nucleus, protons and neutrons, amongst others, themselves have a complicated structure, including a core and an outer envelope. Prof. Veksler said that discovery of this had been a big step forward in the investigation of the nature of matter.

Experiments had shown that there were two kinds of collisions between nuclear particles—peripheral and central.

In the first the proton remains a proton and the neutron a neutron. But in the central collisions protons could be transformed into neutrons and vice versa.

A much larger number of mesons were formed in central collisions, as well as a number of anti-protons (one for every 10,000 to 100,000 mesons). It now appeared practicable, for the first time, to obtain separate beams of mesons and anti-protons, particles with the mass of a proton but a negative charge. This, he said, would enable intensive study of the life and nature of anti-protons in much more reliable conditions than ever before.

FIG. 2. Mr Harold Macmillan looking at laboratory equipment in the Nuclear Research Institute at Dubna during his visit to Russia in March.

600,000 MILES IN 3·3 SECONDS

The giant proton accelerator, when reaching its planned energy of 10,000 million electron-volts—the highest ever produced by artificial means—causes the protons to travel a spiral path of some 600,000 miles in 3·3 seconds—a speed approaching that of light. At present the machine accelerates protons to only 9000 million electron-volts, it is difficult to keep it working at its 10,000 million peak for a long, steady period.

Ten thousand instruments and other pieces of equipment were originally assembled to operate and control the machine. More than 150,000 precision instruments were made to ensure the uniformity of the magnetic field alone because the slightest distortion of the field might have put the machine out of commission.

The circular electro-magnet, which forms the accelerator chamber, weighs 36,000 tons and has an effective diameter of 180 ft.

So far it has been possible to create an intensity of 1000 million high-energy particles per pulse in the machine.

500 "STARS" FORMED IN COLLISIONS

According to Prof. Veksler, one of the first experiments in the accelerator had been the bombardment of photographic emulsion with protons having an energy of 9000 million electron-volts. By tracing the path of these protons, the Dubna physicists established the "inter-action" run—the distance a proton of this energy covers on the average before clashing with atomic nuclei of the emulsion. Up till then nuclear scientists had no such information, Prof. Veksler said.

Results obtained by American scientists on the accelerators of the University of California—the second largest in the world at present—came from the application of energy of 6300 million electron-volts.

About 500 "stars" formed during the Dubna collisions with atomic nuclei in the emulsion were studied and the average number of swift particles (mesons and nucleons) arising proved to be much higher than that previously established by the Americans.

Some of the stars were said to be of great scientific interest, showing the complete fission of silver nuclei, during which all nucleons (protons and neutrons) comprising the nucleus disappeared.

This happened as a result of heating to extreme temperatures in the million-degree range during the absorption of the gigantic energy transmitted from the proton to the nucleus. A number of collisions of primary protons with hydrogen nuclei had also been observed. In these cases, as distinct from all ordinary stars, a narrow beam of rays arises which consists of relativistic particles, evidently mesons, whose life is minutely short.

The Nuclear Problems Laboratory is headed by Prof. Dzhelepov. Working with him is Prof. Bruno Pontecorvo, the former British scientist who left Britain in 1950. Today the Russians call him a prominent Soviet physicist.

Recently he was elected chairman of the scientists' club at Dubna. He leads a research section known as the Pontecorvo group.

The smaller accelerator in the Nuclear Problems Laboratory, weighing 7000 tons, has been converted into a general-purpose unit. It is possible to switch over rapidly from the acceleration of one type of particle to another. Deuterons, the atomic nuclei of heavy hydrogen, are being accelerated up to an energy of 420 million electron-volts and alpha particles are being accelerated up to 820 million electron-volts. In the past three years the intensity of the stream of particles which can be used for experiments outside the accelerating chamber by focusing has been greatly increased as a result of improvements in the machine.

The maximum possible time, 140 hours a week, is being used on the synchrocyclotron for research work.

Prof. Dzhelepov says that scientists in his department have been getting beams of various particles in greater density than ever before achieved anywhere in the world. Valuable information had been obtained about various types of particles and their inter-action with the nuclei of complex atoms.

Prof. Pontecorvo is reported to have made an important contribution in work on installations designed to discover and study new particles.

ISOLATION OF ISOTOPE OF ELEMENT 102

Considerable research in related fields is also being done at Dubna.

Prof. Georgi Flerov, corresponding member of the Soviet Academy of Sciences, told the January session of the scientific council that the main result of work in the laboratory containing the nuclear reactor had been the isolation of an isotope of element 102, having a mass of 253. Research had also been done into the processes of the division of nuclei by heavy ions in the course of reactions. Interesting data had been obtained on the angular distribution of the split particles as well as their kinetic energy. No details have been published on this.

The laboratory staff are getting ready to work on an accelerator of multi-charged ions which is now being built. This, he said, would enable chemical elements not yet listed in the Mendeleyev tables to be synthesised.

Prof. Vadim Soloviev, another research worker at Dubna, is regarded in the Soviet science world as the first man to analyse the problems of the conservation of parity of strong inter-actions and point out the processes in which non-conservation is likely to occur. This work is of great importance in establishing the properties of symmetry of space. (The phenomenon of non-conservation of parity in weak inter-actions was discovered two years ago.)

Prof. Soloviev said that at his suggestion corresponding experiments were being staged at Dubna and at the University of California, Berkeley, United States. He cited this as an example of international co-operation among physicists.

Prof. V. A. Petukov, a Russian, and Eli Kats, a Rumanian engineer, have worked out a method of automatic examination of photographic plates, based on the use of electronic computing machines. This method may make it possible to examine in one day as many plates as could be checked by a microscope in a year.

A Soviet theoretical physicist, Academician Nikolai N. Bogolyubov, won a Lenin prize for presenting what was described as a consistent theory of super-conductivity.

Dubna scientists say that super-conductivity, discovered more than fifty years ago, had not previously been completely explained theoretically. Prof. Bogolyubov, by using a method proposed earlier for the theory of superfluidity, succeeded in producing a monograph on a new method in the theory of super-conductivity; this new method had been effectively applied to nuclear theory.

MOBILE ATOMIC POWER STATION

In the more practical field, one of the most important recent achievements of Soviet nuclear scientists, in which Dubna physicists have played their part, is the completion of a 2000-kW mobile atomic power station. Designed for use on big construction sites removed from conventional power supplies, the reactor of this station is housed in a shell nearly forty inches in diameter and a little over seven feet high.

Water under pressure of 120 atmospheres is being used as a heat transfer agent and moderator in the new station, which is now undergoing full-scale tests.

A 5000-kW fast neutron breeder began operations last year and large-scale atomic power stations are now being built in the Urals, Leningrad, and Vorenezh industrial regions. In addition, a major centre for experimental work on controlled thermonuclear fusion is being built on the Volga, in the Ulyanov region.

Russia has already built various thermonuclear machines, one of which resembles the British ZETA. (See DISCOVERY, 1958, vol. 19, No. 10, p. 402.) Most of the atomic power stations now being built or designed are being equipped with water-moderated and water-cooled reactors.

Meanwhile a steady stream of scientists from abroad has been visiting Dubna, and some have attended conferences there. Recent visitors have included Prof. Harold Urey of the Enrico Fermi Institute, Chicago, and Prof. Stanley Thompson of the University of California, Berkeley.

After his visit, Prof. Urey, one of the discoverers of deuterium, was quoted by Tass, the Soviet news agency, as saying: "I was shaken by everything I have seen here. There are not only excellent accelerators, but an enormous quantity of the most modern experimental equipment . . . one stops in amazement at the huge scale of the research work."

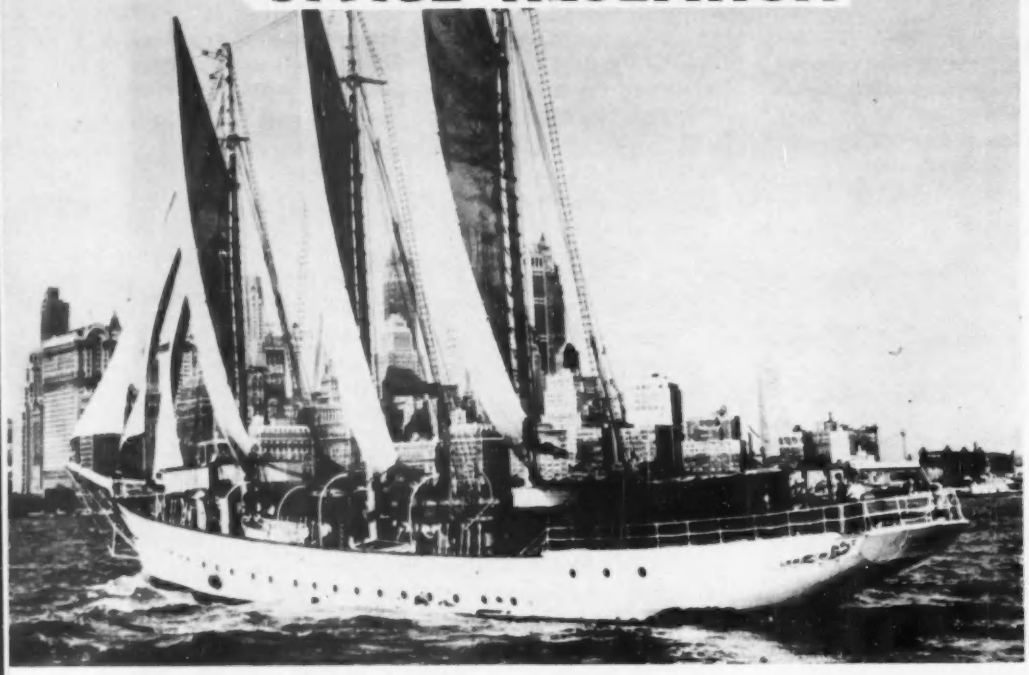
British scientists who have visited Dubna include Sir John Cockcroft, Prof. P. M. S. Blackett, Sir Alexander Todd, and Dr John Fremlin.

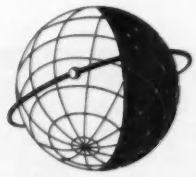
Scientists from Dubna have also been abroad in increasing numbers to attend international conferences. The January session of the Scientific Council was told that the Institute had expanded considerably its contacts with major scientific institutions in the world, including many laboratories in Britain, the United States, India, Japan, France, Italy, and other countries. It is now in correspondence with about 150 addresses abroad.

There is a degree of informal co-operation between CERN and Dubna, though not nearly enough. The interests of all countries dictate that both East and West should co-operate still more in nuclear research.

Our future may well depend upon it.

GEOPHYSICS AND SPACE RESEARCH





By ANGELA CROOME

FIG. 1. The Lamont Geological Observatory's research vessel *Vema* off Manhattan; she is currently engaged, with two other ships, in probing the oceanic area north of Puerto Rico to see whether this is suitable for the Mohole bore, a plan to sink a bore 9 miles down from the ocean surface to reach the Mohorovicic discontinuity, in turn thought to lie 3 miles beneath the ocean floor (DISCOVERY, vol. 20, No. 2, p. 77). The expedition met off Puerto Rico at the end of May.

Should this area prove impractical, investigations will move to the Pacific near Guadeloupe. The Mohole itself is now scheduled for next year.

(Photograph by courtesy of Lamont and the U.S. IGY Office)

Russian Moon Colonies Before 1965?

The Russians expect to land on and explore the Moon by the end of 1965. Academician Alexander Nesmeyanov, the President of the Soviet Academy of Sciences emphasised this during the recent Academy meeting to discuss the contribution of Soviet science to the seven-year plan (this dates from January). It is even possible that a landing on one of the nearer planets may be attempted during this period. It seems that this is the next step in the Soviet space programme after Moon landings.

At this meeting Nesmeyanov devoted ninety minutes to reporting on Soviet space activities. During this report he quite casually mentioned new facts about the Earth's environment that have been revealed by the *Lunik*'s measurements.

Several powerful electric current systems have been discovered between three and four Earth's radii from the surface. This is, of course, many thousands of miles above the highest known layer of the ionosphere. It is suggested by Soviet workers that the newly discovered current systems will help to explain the occurrence of *aurorae* and of magnetic storms.

Measurements from *Sputnik III* and the *Lunik* agreed in showing that the flux of heavy nuclei in cosmic radiation is extremely low.

The space-probe had provided the first experimental data on the density of interplanetary gas, according to Nesmeyanov. He did not, however, elaborate on what this value was.

He explained that his report only covered experiments where the results had already been fully analysed.

U.S. Space Plans for Next Six Months

Though the **three space probes** planned by the Americans for despatch between April and mid-June have had to be postponed, their civilian space agency has some six further satellite firings scheduled for 1959, and, in addition, both the same agency's Project Mercury tests and the Defence Department's *Discoverer* satellite activities are continuing. Events from these programmes may be expected to punctuate the remainder of the year.

The April space probe was to have been a satellite launched into an elongated orbit extending out 30,000 miles into space and principally designed to test equipment for the two later probes which were to be launched in the general direction of Venus in early June when conditions for a Venus shot were at their most favourable for eighteen months. There are indications that the initial space probe may now go off in August, possibly re-aligned as an orbiting lunar probe. Technical problems on both the instrumentation and rocketry sides have proved impossible of solution in the time available since last November when the projects were adopted; hence the postponement. Cosmic rays in space are to be the most important measurement to be made in the 325-lb. payload planned for the orbiting preliminary probe.

Satellite Launchings. Two full-size *Vanguard* satellites remain to complete the scheduled IGY firings. They may be despatched at any time now.

1. The next *Vanguard* due will carry an instrument package, combining another State University of Iowa experiment on charged particles at the edge of space, and measurements of the globe's heat-balance designed by the U.S. Weather Bureau. The ultimate object of this meteorological experiment is to answer the question **"Is the Earth heating up?"** It has been waiting its turn for more than a year.

A proposal on how this heat-balance experiment could be made from a *Vanguard* satellite has come from Prof. V. Suomi of the University of Wisconsin, and Dr Harry Wexler, director of research at the U.S. Weather Bureau. The basic problem is to see whether the incoming radiation from the Sun is matched by the outgoing radiation reflected and emitted from the Earth. The heat that is accumulated by the Earth and its atmosphere is thrown out as radiation in the infra-red

portion of the spectrum. Besides this a certain proportion of the Sun's radiation is reflected by the atmosphere and never reaches us at all.

By placing tiny spheres about the size of ping-pong balls on the ends of the satellite's radio aerials, each sphere to be sensitive to a different range of thermal radiation, it is thought that this basic geophysical book-keeping can be done. One sphere would be white to visible radiation and black to infra-red; another would be black to visible radiation and grey to infra-red; and the third would be black to both visible and infra-red radiation. By measuring the temperature of these three spheres each 30 seconds (which would correspond to about every 150 miles along the satellite's orbit above the Earth) three simultaneous equations could be solved. The result would give the incoming solar radiation, the reflected solar radiation, and the infra-red radiation from the Earth and its atmosphere's absorbed heat.

The net heat-balance is critical to the behaviour of the Earth's atmospheric circulation pattern which may be considered to work like a giant heat-pump with the Sun providing the power, and the air the operating fluid. The equatorial belt provides a convenient cross-section of this giant pump. By monitoring the net-radiation balance over the 60° band (between 30°N and 30°S by the *Vanguard* orbit) much should be learnt about the effect of this on short-term and long-term meteorological changes, "weather" and "climate".

2. The other imminent *Vanguard* satellite will carry three experiments. One will measure the Earth's magnetic field, a second will be concerned with the solar radiations that arrive at the top of the atmosphere (which filters and distorts them to the very different sunlight that we know at the Earth's surface). The third measurement will be of micrometeorite density at satellite heights.

At present the evidence on this meteorite dust as measured by earth satellites is very confused. Values derived by the different calibration techniques in use in the U.S. and Russia have produced density values that vary by a factor of 100. It is partly to clear the situation up that the fresh micrometeorite measurements are being incorporated in this *Vanguard*. As things stand the Russians say there is much less material than expected and the Americans find somewhat more than anticipated.

3. Some of these experiments will be repeated and extended through the longer effective lifetime and greater carrying capacity of a satellite scheduled for launching from a *Juno II* rocket combination equipped with solar batteries. This is also a relic of the IGY programme. The *Juno II* vehicle is that which launched the successful *Pioneer IV* into its orbit round the Sun; it consists of various rocket clusters mounted one above the other on top of a *Jupiter IRBM*. As a satellite-launcher it is estimated to be able to put 100 lb. into a 50° orbit about 1000 miles from the Earth.

4. An elaborate weather satellite is planned for launching into a 300-mile orbit from one of the larger military rockets (such as those of the *Thor* or *Jupiter* family) in about six months' time. Its general principles and objects will be similar to those of February's weather satellite (see these Notes, April issue of DISCOVERY, p. 169) but a specially developed infra-red television camera will replace the rather crude system using a two-photo-cell scanner.

The primary observations will be of patterns of cloud-cover obtained by miniature vidicon television cameras designed by the Radio Corporation of America. One camera will sweep out a path some 1200 miles wide and about 6000 miles long. Ten pictures 1200 miles on each side will be taken on each orbital revolution, and these will overlap to make one strip. There will be 500 television lines per picture so the ground resolution will be

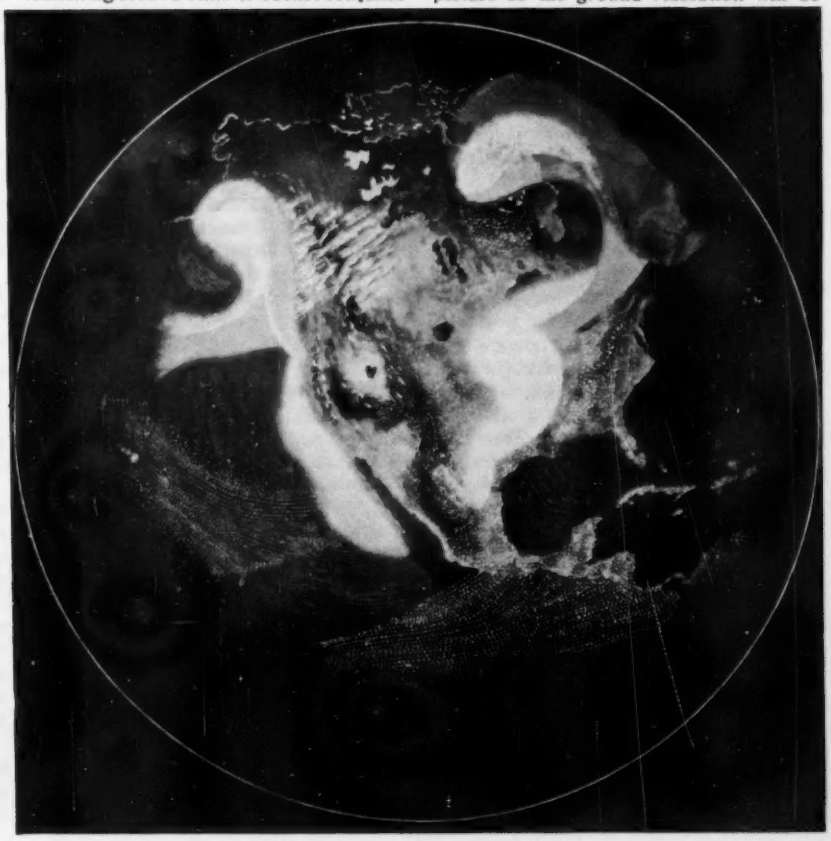


FIG. 2. Features of the Earth's surface and hypothetical cloud systems as they might appear on a black-and-white TV picture taken from a satellite 4000 miles above Amarillo, Texas. The United States plan to launch a large weather satellite carrying such a television system.
(Picture by courtesy of Dr Harry Wexler, U.S. Weather Bureau)

about 2·5 miles. The camera will be sensitive in the red portion of the spectrum so as to reduce the blue light scattered from the Earth's atmosphere. To obtain cloud pictures of higher resolution for comparison, two other cameras with longer focal length will be combined with the primary system. These will cover a smaller ground area though the number of high resolution pictures will be greater—thirty-four pictures per orbit from each camera.

These will be "spot" pictures, taken at the points in the orbit which are most suitable from the point of view both of sunlight and satellite orientation. They will be stored within the satellite on magnetic tape. On passing over one of the stations of a "picket fence" type of ground network the images on the tape will be read back; at least 4 minutes will be required for the read-back in contrast to the 60 seconds needed for the previous cloud-cover scanner and 5 seconds for *Explorer III*'s data play-back.

On the ground the incoming pictures will be recorded twice, once as a video signal on magnetic tape, and again as an image photographed off a screen display. The material will then have to be orientated and located geographically at a central data processing centre before being fed into the forecast and synoptic-analysis systems. The idea is that with this form of recording and transmission the satellite's unparalleled hourly survey of world weather can be in use in a very short time. To be really useful, an hour is estimated as the maximum time that can be allowed to elapse between collecting the information aloft and pumping it out to weather networks.

The system is being developed and will be operated by the Advanced Research Projects Agency of the Defence Department. Some of the components are consequently veiled by security regulations. It seems likely that the satellite would be fired into the new, approximately 83° orbit made possible by the inauguration of the Pacific Missile Range based on Vandenberg Field, California.

Associated with the cloud-cover television system will be a variety of infra-red sensors designed to give spot readings of the heat budget below.

The Americans' ultimate plan (of which the first moves are already being made) is for complete and continuous world weather monitoring, using nine satellites in stable circular orbits. Six of these would travel between 500 and 1000 miles up in Pole-to-Pole orbits; the other three would lie at 22,000 miles in the equatorial plane where effectively they would be stationary over the same points on the Earth. Not many changes in global cloud-cover could escape such a surveillance.

5. Mirrors in the sky. It is envisaged that speedy transmission to a central computing centre of data on this scale may itself be most conveniently managed via satellites. Suitably placed communications satellites could act simply as radio-signal reflectors between widely separated points, or as relays. Plans for testing the "passive" system of communications satellites are already far advanced and we may expect to see the first one in orbit this year, the payload of another *Juno II* rocket. In fact it should be very visible indeed, the estimated brightness being that of Venus. Perhaps another year will bring us satellites that are visible in daytime.

The reason for this spectacular appearance is the spectacular size planned for the object, at least 100 ft. across. The "passive" satellite is effectively a large inflatable balloon made of aluminium-coated plastic. It weighs less than 100 lb. and can be stowed in a couple of cubic feet. Inflated and placed in a 700- to 1000-mile-high orbit it should be a fairly effective reflector to a powerful radio signal. The initial test of the passive system comprehends the use of special equipment for both transmitting and receiving. The Moon, it was recently proved, can act as a reflector of radio signals from point to point on the Earth. It is calculated that artificial satellites can provide smaller moons nearer the earth requiring less transmitter power and less expensive equipment to achieve the same result. Even the wide bandwidth needed for the transmission of commercial television should be possible.

A 10-to-20-passive-satellite system is envisaged for the future by the National Aeronautics and Space Administration (NASA). Any nation could use the satellites as reflectors without interfering with the signals of other nations. Whether dues would be levied, and if so, how unauthorised parties could be prevented from making use of this mirror in the sky, is not clear.

It will also be interesting to see how soon a reflector will need replacing as a result of puncture or merely erosion of the surface, by micrometeorites.

6. One other satellite project is scheduled for launching "in the near future": an experiment to test the **special theory of relativity,** which can be performed by flying a clock, accurate to one part in 100,000,000,000, in an orbit a few hundred miles above the Earth and checking it against a twin clock on the ground. Theory predicts that to an observer on the Earth a clock in a space vehicle would run more slowly than its fellow at the Earth's surface. Conversely, an observer watching the clock in the satellite would think that his clock was running faster than the one on the ground.

This leads to the intriguing question whether an hypothetical space traveller who travels "much faster than light could set out one day in the relative way and arrive the previous night"; or, put another way, whether a space traveller on his return from an extended journey into space at a speed of approximately the velocity of light would find that he had aged less in the period than his twin, but earthbound, brother (DISCOVERY, 1957, vol. 18, pp. 56, 505).

Clocks of the necessary accuracy have been developed recently both here and in the States. They depend upon the regularity of the oscillation of molecules or atoms which is much greater than that of any other motion known in nature. Payload requirements for this satellite experiment are about 1000 lb.

Recoverable Rockets for the Future. Though leading figures in American space science have been appealing to scientists at large for ideas for future space exploration, there is plenty planned for the period immediately following that just outlined and, indeed, up to the era of "soft landings" on the planets. Implementing these plans will depend on the development of the new, specially designed space-science rockets with a much greater payload-to-power ratio at take-off. As already reported (DISCOVERY, 1959, vol. 20, p. 170) enormous sums have already been allocated for this purpose and a number of contracts for the second generation of space rockets have already been placed. (See table.)

NASA plans not only to increase the lifting power of its vehicles but to reduce the relative cost. As a part of this policy studies are going on to find a means of recovering the huge booster rockets of the future after firing.

Life on Mars

"There is almost certainly life on Mars." Dr Gerard de Vaucouleurs, probably the greatest living authority on the planet Mars, gave this as his considered opinion during the recent space research symposium of the U.S. National Academy of Sciences.

His opinion on the possibilities of life on Mars have hardened recently as a result of research done at Lowell Observatory by Dr W. M. Sinton, during the past year. Large dark patches are sometimes visible on Mars through even a small telescope. These regions are known to vary in shape, in colour, and in relative brightness in phase with the Martian seasons. This suggests the annual cycle of plant life.

Now Dr Sinton has observed absorption bands in the infra-red spectrum of these dark regions which correspond with those from heavy organic molecules. The

TABLE OF AMERICAN SPACE-ROCKET PAYLOAD CAPACITIES
(based on table in "The Space Handbook of the 86th U.S. Congress")

	Vanguard	*Jupiter-C*	*Scout*[6]	*Thor/Jupiter* e.g. *Juno II*[1]	*Atlas/Titan* e.g. *Vega*[2] *Centaur*[3]	*Saturn*[4] *Nova*[5]	*Nova cluster*
Take-off weight	22,000	50,000	?	~100,000	~200,000	?	?
Thrust	28,000	75,000	?150,000	~150,000	~300,000	1,500,000	3,000,000
300-mile satellite	20	>30	150	>2,000	>8,000	37,000	75,000
24-hour "stationary" satellite	—	—	20	>600	2,500	11,000	22,000
Moon impact	—	—	—	>800	3,000	13,000	25,000
Moon orbit	—	—	—	>500	1,500	6,000	13,000
Moon landing	—	—	—	>300	1,000	4,000	8,000
Venus/Mars flight	—	—	—	>600	2,500	12,000	23,000
Jupiter flight	—	—	—	>400	>1,500	2,500	5,000
Ready	1959	1959	1960	1959	*Atlas* 1959 *Vega* 1960 *Centaur* 1961+	*Saturn* 1961 *Nova* 1963	1963+

All weights are given in pounds.

NOTES:

[1] *Juno II* is a *Jupiter* rocket combination consisting of *Jupiter*+*Redstone*+solid-propellent rockets.
[2] *Vega*=*Atlas*+*Vanguard* first-stage+JPL storable propellent rocket.
[3] *Centaur*=*Atlas*+exotic-fuel rocket+JPL storable propellent rocket.
[4] *Saturn*=combination of eight *Redstone* and *Jupiter* rockets to give 1,200,000 lb. thrust.
[5] *Nova*=single chamber booster rocket initially yielding 1,000,000 lb. thrust, later 1,500,000, and being specially developed for NASA space research by North American Aviation.
[6] *Scout*=4-stage solid-propellant rocket formed from Aerojet *Seniors*.

raw material for life as we understand it seems, therefore, to be present in the Martian environment.

Passing comment on these findings Dr Sinton described how, after the big dust storm that occurred over Mars at its last close approach to Earth in 1956, the dark patches gradually reappeared through the haze. The way this happened suggested that the dark patches consisted of "something capable of shaking off dust". Leaves naturally come to mind.

Commenting on this, Dr Harold Urey, the famous authority on the composition of the planets, suggested that there was no reason why such muscular movement should be limited to plants.

Studying Venus by Radar

It was recently announced that the Millstone Hill 84-ft. radar of the Lincoln Laboratory, Massachusetts, working under contract to the U.S. Air Force, had succeeded in getting echoes off Venus, This is the first radar "fix" from any object more than a million miles away and the first time radar echoes have been obtained off a planet. The work was actually done in February 1958 at the last close approach of the planet to Earth, but the news was only released this spring. It had taken nine months' computing on a large, high-speed digital computer to extract the returned signals from the background radio noise. The signal-to-noise ratio on this experiment was 1 to 5000.

The object of the experiment was to make an accurate measurement of the distance of Venus from the Earth. The distance was found to be approximately 28 million miles so that the round-trip travelled by the radar echoes was 56 million miles. This compares with a round trip of half a million miles for Moon echoes. It is very important for astronomers to check the astronomical unit, the basic unit used in measuring distance. This unit equals the mean distance from Earth to Sun but this distance is still not known at all precisely. The increased accuracy of radar measurements of distances between the Earth and any of the main bodies in the solar system can help with this calibration problem.

At the close approach of Venus this September the Millstone Hill instrument is to repeat its radar measurements, but with much more sensitive apparatus. The team who will make the measurements not only expect to obtain good echoes from the planet, but are confident that they will succeed in scanning its surface which is permanently hidden from optical telescopes by the dense atmosphere. They expect to be able to tell how much of the surface is smooth, perhaps sea or solid *maria* of the lunar variety, and how much has a rough surface. Changes in surface features no more than 1 metre high should be detectable. "Trees," for instance, will echo differently from mountains. The planet's rate of rotation will also be measured. Jodrell Bank, Cheshire, is preparing for a similar radar programme.

Accelerator in the Sky

Project Argus, the secret explosion by the U.S. last autumn of three small atom bombs 300 miles above the South Atlantic in order to produce an artificial layer of Van Allen radiation was certainly one of the biggest and most expensive experiments in the history of science. It was also one of the boldest. Its conception was due to N. C. Christofilos, an American-born engineer who, some years ago, was working in Athens on lift-design when an idea for a controlled fusion device occurred to him. His fusion strategy, called *Astron*, was finally taken up by the U.S. Atomic Energy Commission and when the first *sputnik* went into orbit, Christofilos realised at once that here was a means of testing *Astron* principles—and much else—without building a machine at all. The

experiment could simply be conducted in the sky where the Earth itself would obligingly provide the main apparatus, a powerful magnetic field of a particular shape. A sufficient number of suitably charged and identifiable particles, electrons, could be conveniently delivered to the right place by an atom-bomb. And so it proved.

All this was confirmed at the special meeting on *Argus*, held as part of the National Academy of Sciences' space research symposium at the end of April in Washington, and which your correspondent had the privilege of attending. Besides the general conclusions already reported (see these Notes, May issue, p. 222), a variety of other geophysical conclusions were drawn at the meeting, as follows:

1. *Man in Space:* The level and lifetime of the radiation from the *Argus* explosions showed that space travellers need not worry about traversing such zones of trapped electrons. From the values derived, Christofilos, however, concluded that the radiation that would be trapped by the explosion of a megaton bomb in space would be a very serious hazard, yielding 100 roentgens an hour dose for a considerable period.

2. *Geomagnetism:* The experiments confirmed theory on the shape of the Earth's field and the effect of this on charged particles. It was found that the low-altitude edge of the artificial radiation "shell" decayed first, and then particles at higher altitudes were shunted lower as a result of scattering off atmospheric particles, until they too were lost. Almost all the electrons in the *Argus* shell "leaked" into the atmosphere over the Atlantic and were lost there as a result of the weak geomagnetic field here. This directly affected the altitude of particles' mirror points bringing them closer to the Earth's surface and therefore into denser air in this region.

Lifetime of Trapped Radiation. It was found that the *Argus III* shell (injected September 6) was still detectable above the cosmic-ray background three months afterwards, when on December 6 the *Pioneer III* space probe passed that way. In contrast, the abrupt disappearance of the *Argus I* and *II* shells after the magnetic storm of September 4 suggests that the disturbance punched holes in the magnetic trap, greatly accelerating the loss of particles.

Reporting on the findings from *Pioneer IV* (launched March 3), Dr Van Allen confirmed that the outer zone of natural radiation that had extended only to 20,000 miles on December 6 stretched out to 52,000 miles on March 3 and that the total number of particles estimated to be trapped in the Earth's magnetic field on that date was three times greater than during the flight of the previous probe. This spectacular change was associated with the large solar flare that pre-dated the *Pioneer IV* probe on February 25.

Atmospheric Density: Satellite data showed that the effective atmospheric density at 600 miles altitude is ten times greater than that extrapolated from satellite "drag" studies. As the *Argus* shells were injected into the unexplained slot between the two Van Allen shells it is possible that the atmospheric density here is anomalously high.

Ionosphere: Argus II and *III* shots produced abrupt decreases in signal-strength of very low-frequency radio transmissions over the Atlantic and an enhancement of the same range of frequencies over the Pacific.

Bonus observation: A "background" rocket, fired from Cape Canaveral on August 15 observed neutron decay electrons that almost certainly were the remnants of a trapped "shell" injected by the high-altitude megaton test over Johnston Island 24 hours before.

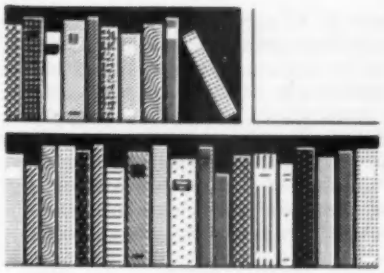
Dr Van Allen has been sufficiently delighted with the geophysical detail produced by *Argus* to be looking forward to more such experiments. He would like *Argus*-type experiments at about 30° intervals between Equator and Poles to fill out the picture of the radiation that bears his name. He told your correspondent that he was trying to think of ways to raise money for such a scheme of firings.

Project Mercury. This American programme to launch a man, some time in 1960, into a 24-hour orbit 150 miles above the Earth in a capsule launched by an *Atlas* missile, is already well advanced. The several aspects of the project are being developed simultaneously. The seven officers to be trained for orbital flight in space were selected in April.

FIG. 3 (*inset*). In a medical test on May 28, two small female monkeys, Able and Baker, achieved the highest altitude, 300 miles, so far attained by mammals which have been successfully recovered. They re-entered the atmosphere in a specially designed nose cone of a *Jupiter* rocket, in the manner of ballistic missiles. Preliminary reports said they appeared to have suffered no physiological damage. Five days later the Rhesus monkey, here shown strapped down for launching, died under anaesthetic while one of the reaction detectors was being removed from beneath her skin.

FIG. 4. A model of the *Mercury* manned-satellite capsule is shown in the Full Scale Tunnel of the Langley Research Centre in Virginia under test to determine its lift, drag, and static stability characteristics. These tests are included in an extensive wind tunnel, laboratory and free flight testing programme designed to result in the optimum shape of the orbital vehicle.

THE BOOKSHELF



The History and Philosophy of Knowledge of the Brain and its Functions

Edited by F. N. L. Poynter, Ph.D., F.L.A. (*Oxford, Blackwell Scientific Publications, 272 pp., 22s.*)

It has been, and indeed still is, a difficult problem to discover the exact function of the various parts of the brain, and to determine the body-mind relationship. The question is made more puzzling by the many fanciful theories propounded through the ages by men with brilliant intellects furnished with few and inaccurate anatomical and physiological facts to guide them. Aristotle thought that the seat of common sensation resided in the heart and, only three hundred years ago, Descartes taught that the soul was situated in the pineal body. The Western scientist who speculates on the meaning of consciousness is amazed that the Eastern mystic ignores the functions of the brain. Yet a study of the growth of knowledge of the functions of the brain is of great interest, and psychologists, physiologists, and clinicians will welcome the publication of the papers read at the Anglo-American Symposium on the "History and Philosophy of Knowledge of the Brain and its Functions", held in London in July 1957.

The names of the contributors are imposing and the range of view is wide, but many of the papers are of pure historical interest.

One of the most erudite essays is that by Macdonald Critchley on the origins of language. He regards language as a new feature in *Homo sapiens*, "qualitative rather than quantitative". After an exhaustive consideration of the many theories on the origin of language, he concludes that "no satisfactory answer to the riddle of the origin of language has yet been made".

In several papers the question of the anatomical basis of consciousness is considered, and here the doctors differ, though all pay tribute to the genius of Hughlings Jackson, whose views, nevertheless, are not always easy of interpretation. Denis Williams points out that Jackson taught that "consciousness is not a function of the highest centres; it is simply concomitant with this function". Sir Russell Brain says that "he [Jackson] does not seem to have envisaged the part played by lower levels in consciousness at all clearly". These statements have significant bearing on modern views. At the beginning of this century it was widely held that consciousness was a function of the cerebral cortex, but the experience of neuro-surgeons and experimental physiologists proved that lesions of the brain stem much lower down (in subthalamic regions) might produce either partial or total loss of consciousness. Walshe, in a brilliant but provocative essay, eloquently comments on the latter view, and is concerned that "the primacy of the cortex as the highest expression of neural evolution is now called in question". He recalls that this view is not new, for a hundred years ago W. B. Carpenter taught that "the sensory ganglia constitute the seat of consciousness" and that "the activity of the vesicular matter of the hemisphere is not attended by consciousness"; while Laycock wrote that "the medulla oblongata is the common sensory of *all* conscious states". Walshe caustically comments on some of the recent hypotheses on consciousness, thought, and "the general integrative function of all nervous systems". Referring to these views, he writes: "These are hypostatised and then obscurely hidden in meagre and primitive cell groups in the brain stem, from which retreats, in modes unknown and by paths undiscovered, they are proclaimed to exercise an overall supremacy in the nervous system. Common sense, no less than science, cries out against these neuro-mythological exercises."

Whether one agrees with Walshe or not, one cannot forbear admiration of his eloquence and dexterity in argument.

Z. COPE

Oceanography and Marine Biology

By H. Barnes (*London, George Allen & Unwin, Ltd, 1959, 218 pp., 35s.*)

It would hardly be possible in these days to write one single book on the instruments of physical oceanography which could be all-embracing in respect even of current-meters alone. When other divisions of the instrumentation of physical oceanography are to be dealt with as well and the methods of marine biology also included, an author must needs set himself a special target and be skilfully selective as to material. What was particularly needed at the present time was a well-balanced book of modest size which could be placed in the hands of persons charged to "get oceanography going" where little has been done so far and where funds and facilities are small. Dr Barnes has done a considerable service in writing the book under notice. It is clearly written and is supplied with painstaking descriptions of such things as echo-sounding. The writer has done well to give sketches of his own making to illustrate in detail the working parts of various much-used instruments. Only a few spelling errors occur; amongst these is the name of Mr G. R. Forster. A careless mistake is made on p. 61 where the two parts of Fig. 27 wrongly purport to be of the same instrument. Part (*a*) shows the "scoopfish", but part (*b*) shows the Lafond/Dietz snapper. Dr Barnes does so well in keeping to his prime concern (stated on p. 159) "with problems involved in making observations and measurements within the marine environment" that it may seem a little ungenerous to wish that he had illustrated a more-modern version of the renowned Ekman current-meter.

The descriptions of plankton-collecting methods are well done and are up to date; those of sediment sampling are also to be much commended.

In the space available, what is told and advised about current-measuring is realistic and sound, and includes a welcome account in simple terms of the method of towed electrodes. On a point of history one questions the need to credit the Americans with the discovery of the deep-scattering layer. Dr Barnes does well to include the chapter on "Photography and Television" despite his having wondered whether such a section should properly appear. On television the reader gets the views of one who has had much experience.

We now look forward to the appearance of Dr Barnes' forthcoming book on the chemical side of Oceanography.

J. N. CARRUTHERS

Handbook of Automation, Computation and Control

Vol. 1: "Control Fundamentals", edited by Grabbe, Ramo, and Wooldridge (*John Wiley, 974 pp., £6 16s.*)

This is the first of a series of three volumes: Volumes 2 and 3 are to be entitled, "Computers and Data Processing" and "Systems and Components" respectively. The aim of the series is to ". . . gather together in one place the available theory and information on general mathematics, feedback control, computers, data processing, and system design" for the use of practising scientists, technologists, and managers in these fields.

The need for such a handbook is not

open to doubt. It is just into these subjects of Automation, Computation, and Control that a large proportion of this country's, and the United States', scientific effort has gone in the post-war years, with the result that their development has been extraordinarily rapid and has covered an extremely wide field. It is therefore difficult for the worker to keep pace with all developments in his own sphere, let alone related ones. The situation is made worse by the, necessarily, secret nature of many of the new discoveries.

A book which summarises and collates, intelligently, these advances will be of great value. On the evidence of Volume I of the handbook we can rely on Drs Grabbe, Ramo, and Wooldridge to meet this need.

The subject headings in "Control Fundamentals" are: (*a*) General Mathematics, (*b*) Numerical Analysis, (*c*) Operations Research, (*d*) Information Theory and Transmission, and (*e*) Feedback Control.

Section (*a*) deals with those topics usually read for an Honours degree in Mathematics. Techniques are briefly explained and references given to the literature, but few examples are worked. Probability Theory and Statistics could be given more space: it is just on these subjects, rather than on Mathematics proper, that both the engineer and mathematician are least well informed.

At least two methods of solving the more common types of problem met with in Numerical Analysis are given. For example, the Cote's and Gauss methods of quadrature and the Adams-Bashforth and Runge-Kutta methods of integration are discussed. The one apparent omission is that methods of computing the roots of polynomial equations are not given. This is a continually recurring problem in the analysis of control systems and is, at the least, necessary as a check on root locus plots.

A more serious criticism is the dismissal of Operations Research in one chapter. This suggests that the series will be directed more to those system analysts dealing with "hardware" rather than to those concerned with military and business operations. One hopes that succeeding volumes will redress this imbalance. Simple inventory models are analysed, but no mention is made of the Constant Reorder Interval rule. This would surely have been an ideal example to illustrate the relation between business and feedback control systems. Linear programming and transportation techniques are given at length, but no reference is made to Dynamic Programming.

The section on Feedback Control, which occupies about one-half of the book, is very good. Excellent summaries on typical component equations, analogous elements, transfer functions, error detectors and correctors, and power amplifiers are given. Two chapters are devoted to stability criteria and the relationship between transient and frequency responses. The effect of noise on control systems is given only a brief mention, and the only optimisation criterion mentioned is mean square error, but there is a detailed treatment of non-linear systems.

These are detailed criticisms of a book which is generally excellent. We await the succeeding volumes with great interest.

P. L. V. HICKMAN

A New Approach to Schizophrenia: an Important Contribution to the Diagnosis and Treatment of Schizophrenia

By Julius I. Steinfeld, M.D. (*London, Hutchinson Medical Publications, 1958, 160 pp., 21s.*)

Schizophrenia is becoming a fashionable word. It has found favour recently with politicians, writers, and architects; even the Public Orator has used it at an Oxford Encaenia. This newly gained popularity has not enhanced its scientific merits. Since its introduction into psychological medicine nearly fifty years ago schizophrenia has largely superseded dementia praecox as a convenient label for a heterogeneous group of serious mental disorders. Because they are relatively frequent, afflict principally young people and often cause severe incapacity, these illnesses have attracted much research and speculation from workers in many fields. Their nature and rational treatment have unfortunately remained elusive and in this state of uncertainty many theories of causation have been adduced which derive from speculation rather than from clinical or experimental evidence.

Dr Steinfeld gives little evidence. His views are based, as he admits, on the postulate of certain hypothetical events in early infant life which he calls the "hunger trauma". This would appear to be little more than under-feeding for a period of about one week, but the degree of malnutrition is not specified and it may be objected, reasonably enough, that only a small proportion of those individuals who suffer deprivation go on to become schizophrenic. Dr Steinfeld meets this objection by asserting that the schizophrenic reaction, "is a matter of degree and depends on intensity of the early stimuli, and equally it is a matter of 'diencephalic resistance' which finally determines whether or not an individual, conditioned at an early age, develops psychotic behaviour". He attempts to buttress his *post hoc* argument by reference to scattered physiological observations in support of a premise which is rooted in psychoanalytic theory. He even extends his hypothesis in an attempt to embrace phenomena as diverse as masochism, homosexuality, alcoholism, and cancer. Finally, he goes on to make suggestions in the field of prophylaxis and treatment.

A book of this sort demonstrates most of the errors which have bedevilled the scientific study of schizophrenia for many years. It is unlikely that the medical reader, unless he shares the author's bias, will regard Dr Steinfeld's approach as new or his contribution as important. Non-medical readers, however, may be sufficiently attracted by topical interest in the subject to be less critical of the author's opinions. They should consult modern textbooks of psychiatry where our knowledge of and ignorance about the schizophrenic illnesses can be studied.

M. SHEPHERD

Die Idee der deutschen Universität: Die fünf Grundschriften aus der Zeit ihrer Neugründung durch klassischen Idealismus und romantischen Realismus.

Five Essays from the Times of their Re-Foundation by the German Classical Idealists and Romantic Realists (*Darmstadt, H. Gentner, 1956, 386 pp.*)

This is not intended to be a thorough investigation into the nature of the ideals of German universities, as exemplified by some of the leading minds of the early 19th century. This little, tightly packed book is an anthology comprising lectures given by:

Schelling (Methods of Academic Study).
Fichte (Plan of a University in Berlin).
Schleiermacher (Occasional Thoughts on Universities from a German Point of View).
Steffens (On the Idea of Universities).
Humboldt (*W.v.*) (On the Organisation of the Institutes of Higher Learning in Berlin).

This is the content of the collection and it is good measure indeed. Reading these early pronouncements and programmes, one becomes aware of the long way society, especially British society, has travelled since. There is no doubt that the German universities of today, looking for new orientations, harken back to the old days, attempt here to find some fundamental directives. To many of the present-day protagonists of German university ideals, these and other men (but these first of all) laid the foundation stones for the development of German scientific and scholarly contributions; they were the founders of an idealism to which German youth, they feel, should turn for ultimate values. Much indeed would need re-examining before these ideals could be adapted to any contemporary

society, but the appearance of the book at this juncture in Germany, sheds some light upon the state of groping and inherent retrospection among university thinkers.

British theorists have in one convenient volume some of the leading thoughts on university education, as proffered in the 19th century, and largely effective on the Continent and partly in the United States. Let the introducer have the final word:

"Since 1945 there is no pause in the cry for a reform of the German university. The swelled number of students, the incommensurate teaching staffs, the overgrown seminar numbers and the aloofness of professors and the mass of undergraduates—the demands of day-to-day routine and the urge to complete studies as soon as possible; the lack of general education, the far too small grants to seminars and institutes: These are the problems of the moment. It would indeed be bad for the German university if a remedy were to be sought merely on these grounds. For this would mean a misconception of the crisis altogether, for the university would . . . still be removed from its central purpose and meaning: it could then least of all be the organ of healing in the great spiritual and structural crisis: for its organising centre is its inner unity, the unity of ethical-moral enquiry and research, the united, albeit departmentalised, penetration into the texture of reality, both of the world and man."

J. HORNE

Big Molecules

By Sir Harry Melville, (*London, G. Bell & Sons Ltd, 1958, 180 pp., 15s.*)

This entertaining little book is an account of Sir Harry Melville's Christmas lectures on plastics and related macromolecules, given recently at the Royal Institution. As most readers will appreciate, these lectures are intended for young people just about to embark on a scientific career and consequently very little fundamental knowledge is required for their appreciation. The first chapter deals in an elementary fashion with the underlying chemistry and the second with the physical properties concerned with measurement of the size of these molecules. There follows an account of fibres, rubbers, plastics, and polymers dealing with methods of manufacture, properties, and behaviour and exemplified by many examples of industrial application. There are several excellent illustrations, including photographs of the production of nylon threads and the use of synthetic glues in aircraft manufacture as well as one of the wheels of the Royal State Coach which are "trued" by the use of synthetic adhesives. The style is clear and lucid throughout and the book can be recommended strongly to all who wish for a concise account of this important section of chemical industry.

A. W. JOHNSON

Can Man be Modified?

By Jean Rostand, trans. by J. Griffin (*London, Secker and Warburg, 1959, 105 pp., 10s. 6d.*)

Jean Rostand's popular writings are lively and are infused with the desire to bring biology into its proper relationship to all other humane studies. In these respects he is the French writer nearest in spirit to our own J. S. Huxley or J. B. S. Haldane, but he is not their equal in accomplishment.

The present book surveys what is, or may shortly become, biologically possible in the way of controlling man's nature, and discusses how far such control can be morally and socially justified. The treatment is discursive and not always wholly accurate, but the opinions expressed are, in my view, sensible. The translation is occasionally unhappy, as when semen "endures a condition of vitrifying congealment . . . ." rather than "survives freezing".

D. R. NEWTH

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The Technical Writer

By J. W. Godfrey and G. Parr (*London, Chapman and Hall, 1959, 340 pp., 45s.*)

Just because everyone learns to write at school, we are all certain that we can do it, in fact we think we know how to do it perfectly. We are convinced that there is no need to learn it again when we have to put forward scientific and technical thoughts, and yet how mistaken we technical and scientific writers are!

Writing, like any other art or technique of communication, must be painfully learnt by practice. As in every other craft, perfection is only achieved by constant attention to detail; feeling for the beauty of language, and for style—once defined as having something to say and then saying it as simply and as clearly as possible—comes only after years, and then only to some fortunate few. A superb example, which cannot be quoted too often, is Sir Charles Sherrington's description of the sleeping and awakening brain: "Swiftly the head becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern: always a meaningful pattern, although never an abiding one. The brain is waking, and with it the mind is returning."

Godfrey and Parr's book, written with a deep feeling for style and presentation, is to be highly welcomed. Not only does it again set out the best techniques of writing, style, and preparation of manuscripts, but it goes a good deal further by showing the writer what happens to his work once it has left him. Information on setting out of the text, editorial procedure, typography, and printing, and finally some very sound advice about copyright, indexing, agreements, reprints, and translations all combine to give the book a completeness which cannot be equalled by any previous works on this subject; a critical bibliography of such previous works forms a most useful fifteen-page appendix for the reader who wants to follow up any specific details. Particular praise must be given to the choice of examples, widely spread throughout the text; the hypothetical case of copyright complications reads indeed like a thriller.

However excellent, the book is not free from faults. On p. 47 one reads, "The exact wording of the title must be carefully chosen if the reader is not to be misled." Unfortunately, the title of the book itself is too narrow in conception, for the *scientific* as well as the technical writer can gain a great deal from reading this work. Admittedly, if the title had included the word scientific, then the examples would have to be chosen from a wider field, which could have been done easily; as it is, already the book jacket gives the misleading impression of narrow technical documentation. The authors have deprived themselves of a large market of sales, and many scientific writers may be deprived of sound advice.

Perhaps two further small points should be mentioned here. The writing of the preface was so beautifully set out in "Praise of the Preface"—a mere pamphlet of John Wiley's—that one is surprised that the authors have not mentioned it. Secondly, the good practice of many American publishers of giving a biography of the author on the book jacket should have been given more emphasis in the text; this information helps reader, editor, and reviewer.

These small points do not detract from this excellent work. All scientific and technical writers and all contributors to DISCOVERY should study it most carefully before submitting their manuscripts to an editor.

A. R. MICHAELIS

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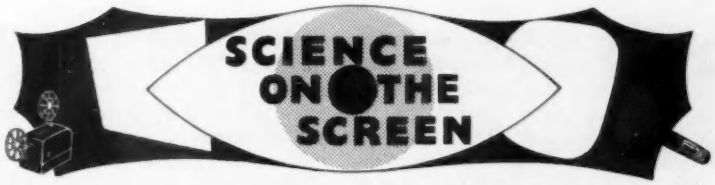


Science and Technology at Harrogate Film Festival

"When I travel around the world I usually take one or two films with me," said Sir John Cockcroft, at the recent Harrogate Festival of Films in the Service of Industry (April 21–25). He did so, he explained, because there was an ever-growing need for the scientist not only to communicate with other scientists but also to make himself clearly understood by the ordinary man "who has an inferiority complex about science".

And it was significant that the British Association for the Advancement of Science which, since its foundation in 1831, has aimed at presenting science to the general public, was this year presenting two awards at the Festival. Its Diploma of Merit for the British film shown at Harrogate which provided the best exposition of the scientific principles underlying an industrial process went to *Schlieren*, made by the Shell Film Unit. The making of this film was itself a tribute to the interest in technical subjects which this medium can arouse among many different audiences. In *High Speed Flight, Part 1—Approaching the Speed of Sound*, Shell had used the schlieren system to demonstrate air flow round an aerofoil. So much interest had been aroused in this cinematic technique that the unit made *Schlieren* to explain it to a wide audience.

Schlieren means internal streaks. In the 19th century it was discovered that the refraction of light occasioned by faults in glass enabled them to be photographed and revealed in greater detail than had hitherto been possible. The technique is now widely used in aerodynamic research. A light-beam is focused via a condenser on to a concave mirror which passes it through pure glass panels in the wind tunnel on to another concave mirror which brings it back to a focus. If at this point a three-coloured filter is so positioned that the light passes through the very narrow central strip, then a uniform background colour can be recorded on film. Changes in air pressure or temperature in the wind tunnel will deflect the light-beam so that it will then pass through one or other of the outside colour panels in the filter, and thus be recorded in a different colour against the uniform background. In this way air expansion (which is gradual) is revealed as areas of colour and shock-waves (which are sudden) appear as strong lines of colour.

The film shows examples of aerodynamic studies, shock-waves round a wing section, aileron "buzz", air flow round a model aircraft at twice the speed of sound; flow-pattern round a simple wedge, useful for hypersonic aircraft; and air flow from nozzles, useful in rocket research. Many examples are given which would be of great interest to teachers of physics—air flow round a human hand or an ice-cream; the mixing of two colourless liquids; sugar dissolving in water; the shock-wave created by a sparking-plug; even the air flow from the vents of a recorder playing "Pop Goes the Weasel!"

British Transport's *Between the Tides* won the other B.A. Diploma of Merit for the best presentation of science to the public—a beautifully photographed and edited study of marine life on the Pembrokeshire coast, marred only for some by a rather extravagant commentary, although beautifully and interestingly delivered.

Other excellent examples of popular expositions of scientific and technical subjects were Buckland Smith's study for the UKAEA, *Radioisotopes in Industry*, which gave some instances of their cur-

Photograph from the film, *Between the Tides*, made by the British Transport Film Unit.

rent use—tracing silt-flow in the Thames, checking on sand-mixing at a glassworks or tracing pipe leaks in a methane gas plant; Esso's *Your Petrol Today*, with its interesting account of petrol-blending studies, based on the fact that petrol has a boiling-range and not a boiling-point; the Gas Council's study of modern gas-research work (into such problems as flame behaviour, thermal efficiency, or refrigeration) *Paths of Progress;* or the very competent British Transport film *Rail Stress*, showing research on the impact effects around the fishbolt holes of steel rails occasioned by the passage of rolling-stock wheels—effects accentuated by the multi-small-wheel bogies of the new diesel and electric locomotives now coming into service.

In showing x-ray crystallographic studies, ICI's new film, *Crystallisation*, merely did very well what has often been achieved before. Its novelty lay in its very effective attempt to relate the work of the school laboratory to modern industrial practice, notably in an excellent sequence comparing crystallisation of sodium thiosulphate in the school with the Passburg Rocking Crystalliser in industry.

Mullard and EFVA continued to show what effective collaboration between industrial and educational film sponsors can achieve—with *Conquest of the Atom*, an account of the work of Thomson, Rutherford, Cockcroft, and Chadwick, which won the award for the best film in the category for Education and Training within Industry.

The industrial worker's closest contact with the application of scientific principles is in Work Study. This year's crop of films was rather disappointing, and notably in the case of the British Productivity film, *Work Study Aids Builders*, showed a rather stereotyped and unimaginative approach. Incidentally, a sequence in this film on the handling of bricks on a hoist compared very unfavourably with the unpretentious but effective study of similar problems in the Building Research Station's film *Handling Bricks in Packages*, which got an Honourable Mention. But the prizewinner in this category, the British Productivity Council's *Variety Reduction*, well deserved its award—a study of a higher management conference with a work-study specialist, doubtless inspired by Henry Fonda's *Twelve Angry Men*. Nor is the analogy too extravagant, because the writer knows of one large firm which purchased a copy of the latter film for use on human relations courses!

Significantly the most original film treatments were in the field of sales promotion—*Bandwagon*, World Wide's *tour de force* for the Ford Motor Co., winning the Category "C" award, whilst another film for Ford's, *Your Automatic Choice*, also had its inspired moments. Most novel of the very few cartoons was *The Owl and Fred Jones*, entered in the Human Relations and Welfare category, but really a public relations film in intent. It was disappointing, therefore, not to find at Harrogate, Ford's latest effort, *The Story of the Motor Car Engine*. This is a bad title for a film which merely explains the principle of the four-stroke internal combustion engine. But its manner of doing this merits attention—a film which attempts in crazy cartoons to get a technical idea across by imaginative repetition. This is really film doing the job it is best fitted to do—presenting ideas visually. Maybe there is a moral to be learned here for the average industrial film viewer. As Sir John Cockcroft said with reference to his fellow scientists:

> "Many of us are learning by painful experience the techniques of being understood. I am not sure there is a similar push on the other side by the ordinary man."
>
> A. HUGHES

Television during May

Once more it must be reported, with much regret indeed, that of late, science television broadcasting for the adult, on the ITV channel has been practically moribund. Week after week, nay, month after month goes by and all we see are the routine school broadcasts, plus one regular 19-minute programme on Sundays at 5.50 called "It Can Happen Tomorrow". I am told (whether rightly or wrongly I do not know) that the real target of this broadcast is not an adult audience, but an audience of teenagers. It would be interesting to know just how many teenagers are ready to surrender Sunday after tea-time for a science broadcast. These broadcasts, which are usually delivered by Gerald Leach, are admirable in their own way. Mr Leach is a sympathetic and serious broadcaster; he manages to cope extremely well with a formidably wide range of material.

But the fact remains that despite the enormous audience held, and ignoring the vast resources available to it, the ITV organisations just do not seem either to wish to broadcast continuous serious science series for adults nor do they consider that they have a duty to do so. What is particularly astonishing is that these experts in the field of supplying entertainment (their profits are proportional to their skill) should fail to recognise that science programmes, if correctly handled, can be highly entertaining as well as instructive. If it be accepted that entertainment is the primary objective in ITV, this objective can still be achieved in a cunningly planned informative science broadcast. We do not even see regular science fiction nowadays on ITV, much less serious contributions for thinking people. Surely one would have thought that science fiction would hold a huge audience, and whilst good science fiction is no alternative to a proper adult informative science broadcast, even such fiction is infinitely to be preferred to the incessant dreary focus on crime, on the prize-money quiz, and on the inevitable "pop" programmes.

The BBC on the contrary, nobly maintains a steady output of adult science television. "Eye on Research" continues steadily in its new edition, the time allotted to it being 9.30 p.m. The fortnightly science magazine programme "Science is News" still continues to entertain us. This has been moved to 10.15 p.m. which is rather a pity, for not only are the young all in bed by then (or should be), but Mother is often occupied at so late an hour either getting youth to bed, or preparing domestic matters for the next day, Hans and Lotte Hass bring exciting real live biology, with their underwater cameras, direct to us with the fascination of ocean life. Clearly this can of necessity only be film. For those inclined that way there is usually a psychiatric discussion somewhere; and, of course, in addition the schools, too, keep up their flow of science.

"Science is News" keeps giving us a bewildering variety, and here we really do often have information and entertainment skilfully wedded. The only criticism one is inclined to level at this magazine programme is that occasionally (not often) there is a surfeit of film in some items. Thus in the sixteenth programme of the current series, three subjects were dealt with: (*a*) the heart-lung machine, (*b*) radioisotopes, (*c*) volcanoes. The heart-lung machine was "hot" news at the time because of the concurrent visit of surgeons to Russia to demonstrate the "hole-in-the-heart" operation. This was a timely broadcast and was well illustrated with Mr Alfred Wurmser's typically clever animated diagrams. A novel camera angle was adopted in one instance; looking down on a diagram on a table. This proved effective. The second section, that on radioisotopes, was one of those rarer occasions when Mr McCloy used too much film. It was, in fact, virtually *all* film on the use of radioactive tracers. Interesting though this may have been to some, film is not real live television and is not the best way to exploit the medium. A "live" use of tracers with a demonstration, occupying, perhaps, some minutes, would have had a bigger impact.

In characteristic contrast, the third item, a quick review of the fundamentals of

vulcanology by Dr Gaskell, was delightfully live and exciting.The broadcaster was full of enthusiasm for his subject, and whilst producing some intriguing model active volcanoes, succeeded in conveying across a sense of excitement as the burning models built up surprisingly close resemblances to different kinds of real volcano. Here too, film was exploited, but the film was, in this case, subsidiary to the main interest, which was *the man before the camera.* This is undoubtedly an admirable way to exploit film, but if film occupies some 80% of the whole time of a particular item, the balance is wrong, for the medium of television is not being used to best advantage. This is a relatively rare defect in "Science is News", but it did occur on May 28.

S. TOLANSKY

LETTERS TO THE EDITOR

Interferometric Technique

Sir:

I have noticed that in your journal DISCOVERY, April 1959, vol 20, No. 4, an eclipse plate is published which Dr H. von Klüber, Cambridge Observatory, and Dr A. H. Jarrett, University Observatory, St Andrews, made during a combined eclipse expedition to Atafu at the last eclipse of the Sun.

Since this special interferometric technique, which for the first time has been successfully applied in corona-observation, was originally devised by Dr Jarrett (see *The Observatory*, October 1955, No. 888, p. 203, in which Dr Jarrett gives his account on "Interferometric Measurements of the Green Corona Line during the total Solar Eclipse 1954 June 30", to the Royal Astronomical Society of London), and since the plate published by your journal was actually exposed by Dr Jarrett in collaboration with Dr von Klüber at Atafu, I think there can be no doubt that Dr Jarrett's name and that of the University Observatory of St Andrews have to be given besides that of the Observatory of Cambridge.

PROF. E. FINLAY FREUNDLICH

Director of Observatory.
The University of St Andrews.

Lines of Communication

Sir:

I read with great interest Geoffrey Parr's advice on the presentation of technical information (DISCOVERY, 1959, vol. 20, No. 5, p. 199).

My theme is the newly emerging role of the popular science reporter as a key link in the lines of communication between scientist and scientist: not only between scientist and layman.

We are all agreed that our society is dependent on the speed of communication of information: on the efficiency with which not only the new, but even the old, is made available to those who need it. Without accumulated information we cannot survive, but without current information we cannot function effectively. Not so many years ago this was far less true.

Today, however, political, social, and economic decisions can only be made on the basis of the latest information. Efficient lines of communication are the lifeblood of our society.

Bound up with the problem of communication is that of understanding what is being communicated. Sir John Cockcroft, speaking at the Harrogate Films for Industry Festival, pointed out that "the mind of the scientist is surprised and impressed by the rate of development of the applications of science . . . he too has his problems of understanding."

When, thirty years ago, he worked in the Cavendish Laboratory under Lord Rutherford, he went on, "we were a group of thirty to forty comparatively young scientists working in one of the growing fields of science, nuclear physics. It was possible to know not only everything going on inside the Cavendish Laboratory, but also to know most of the workers in this field throughout the world.

"After the war, I became Director of Harwell and saw it grow to a staff of over 5000 whilst the Atomic Energy Authority as a whole built up to a strength of 30,000 and became a great national industry. During this time the interests of physicists such as myself had to widen to take in radio-chemistry, metallurgy, biology, and nuclear engineering at the same time as nuclear physics, which was still on the frontiers of science and developing fast. Scientists have therefore to learn to understand, at least in broad outline, what their fellow scientists are doing."

Unfortunately, they can receive very little help from their fellow scientists. Few scientists can convey information either to other scientists or to the non-scientist. Mr Mel Thistle, Director of Public Relations of the National Research Council of Canada, estimates they can convey only about 1% of what they know. Of that 1%, perhaps three-quarters is out for security reasons, which leaves one-quarter of 1%.

For the scientist there is a delay lag between new information and its acquisition by him. This is an old story. In 1948, the Royal Society Conference on Scientific Information Services dealt with this and a whole range of problems, and last November in Washington an International Conference on Scientific Information (DISCOVERY, 1959, vol. 20, No. 2, p. 60) was concerned with current research and problems of the storage and retrieval of information.

There were no formal decisions taken at this conference and until its influence is expressed in some way as yet undefined, we are where we were. What did emerge, Dr D. C. Martin points out (*Nature*, vol. 183, No. 4655, p. 147), "was that communication of scientific information is done as much through personal conversation as by reading the literature." As the volume of scientific literature is doubling every seven years, it is clear that reading to be done effectively must become more time-consuming. (See DISCOVERY, 1959, vol. 20, No. 3, p. 110.)

It is with the background above that we should re-examine the role of the popular science writer, and of the significance of the presentation of science through the media of mass communication.

In lectures to research workers, I have in recent months endeavoured to discover what are their sources of information about what is happening in science and technology generally. I have found their sources are the same as those of the non-scientists—that is, the Press, TV, radio, exhibitions, films, and books. These popular forms of the presentation of science are of key importance in our lines of science communication. They are as significant for the scientist as for the non-scientist.

That is why the appointment by the BBC of a Science Correspondent attached to the News Division is to be welcomed. Mr C. L. Boltz will be responsible for science news reporting on both sound and television services. This appointment marks a great step forward by the BBC in the presentation of science to mass audiences. It makes science equal with politics, industry, and sport.

I know of no study made in this country to indicate the extent to which the scientist gets his general—not specialist—information about what is happening in science from the mass media. Such research requires to be undertaken, for it may well indicate that solutions to the problems of communication to scientists are bound up with the popular presentation of science. Good popular science reporting helps the scientist as much as it does the non-scientist.

What is needed for the scientist, I suspect, is the equivalent of the newspaper's midday sports or racing special. This gives the punter each day the very latest information in a form he can understand and use immediately. These are the needs of the scientist. I believe we must now examine the extent to which these needs are being met by, and can only be met by, the popular presentation of science.

MAURICE GOLDSMITH

Science Information Service, London.

FAR AND NEAR

Science in Parliament: April 20–May 15

A busy period of scientific interest preceded the Whitsun recess. Apart from routine questions on co-ordination of building research, road accident research, work-study in the RAF, nuclear propulsion, relations of DSIR to small firms, improvements by the Water Pollution Research Laboratory of sewage-purification plant, and references by the Minister of Labour in an Adjournment Debate (May 1) to the wide range of studies by the DSIR and universities on automation, questions were asked about radioactivity. Of special interest was an answer of the Prime Minister's (April 28), accompanied by a written statement which he circulated in the Official Report. Though too complex to summarise here, the statement dealt with the disturbing fact that since May 1958 there had in the U.K. been a doubling in the rate of deposition of strontium-90 in rainfall. During further questioning (notably May 7 and 12) the Prime Minister stressed, by way of reassurance, that radiation from nuclear tests accounted for slightly more than 1 unit compared with 22 units from other man-made radiation, and 100 units from natural radiation. Yet some members were concerned to inquire how far it was safe to assume the existence of a safety threshold for radiation at all.

Arising from the Committee stage of the Nuclear Installations (Licensing and Insurance) Bill, the Prime Minister was twice questioned (April 22 and 28) by an anxious Opposition on the possibility that private companies were to be permitted to manufacture nuclear fuel elements. He gave assurances that except for certain matters of processing, the materials would for many years continue to be supplied by the Atomic Energy Authority or the Defence departments. He conceded, however, that a purpose of the Bill was to ensure that a proper system of licensing and control would be enforced if it should ever arise that any processing and manufacture were to be undertaken by private enterprise.

In a Debate (May 4) on the need for a fuel and power policy, leading Opposition spokesmen were concerned at the scientific and research aspects and were particularly alarmed that the gas industry had paid insufficient attention to research into coal gasification, that the National Coal Board had not made further progress with its researches into coal by-products and that official estimates regarding the relative cheapness of nuclear over coal power by 1965 had not been sufficiently examined. The Government, for their part, drew attention to some positive efforts in gasification research programmes.

Finally, space research: following an Adjournment Debate (April 29), when an Opposition spokesman expressed concern that "we might publicly contract out of one of the major engineering and scientific adventures of our time", the Prime Minister announced (May 12) a programme for the design and construction of instruments to be carried in earth-satellites. Regarding launching these, there might be scope for joint action with the U.S., the Commonwealth, or other organisations. Studies of the British military rocket were to be prepared in the event of an all-British effort. Co-ordination with the Soviet Government would be raised at a summit meeting. The British Government's present intentions are, regrettably, clear. They are to spend "a substantial but modest sum, more in hundreds of thousands than in millions".

N.C.R. Interplanetary Display

To commemorate their 75th anniversary, the National Cash Register Co. had a window display which endeavoured to tell the continuous story of past, present, and future space exploration.

Although a large percentage of the display was pictorial, there were a number of interesting scale-models which included the English Electric *Thunderbird* and the *Migrant* rocket. One window indicated the type of present-day rocket vehicles, the largest is the *Atlas* which recently orbited the Earth carrying a Christmas message from President Eisenhower. The *Atlas* is capable of launching very large satellites and, if used as a first-stage booster-rocket, could send payloads to orbit the moon.

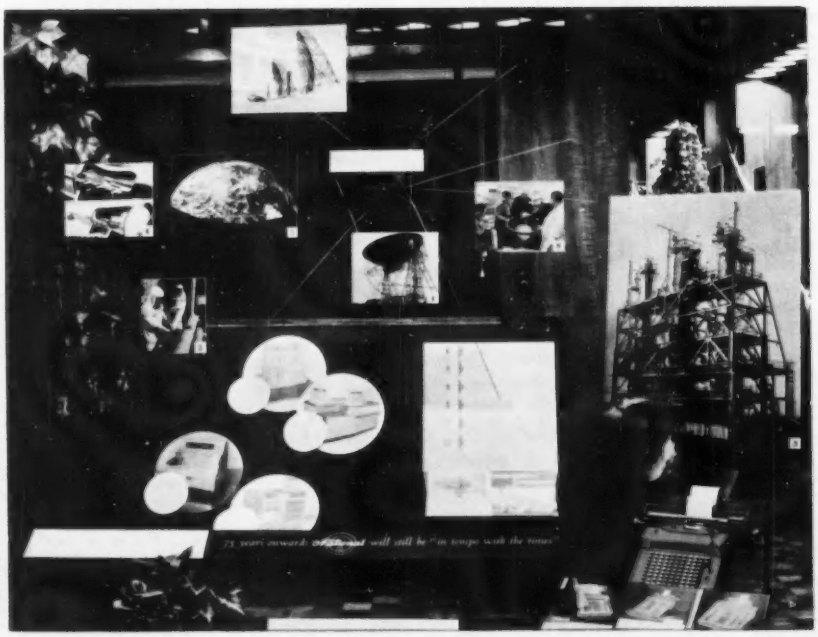
Another window dealt with satellites and "probes", and referred to the various American and Russian satellites launched up to the present time. A diagrammatic illustration compared the *Atlas* with the *Titan*, an immense rocket which would be capable of sending up large satellites and manned vehicles without difficulty.

Future rocket vehicles were featured. At the present time few of these have immediate application, though the nuclear-powered rocket is of immense potential importance and preliminary studies under project *Rover* are being carried out in America to develop vehicles of this type.

Some indication of the tracking and testing equipment used at the present time was shown. It could, however, only give a modest indication of the highly specialised equipment required for missile work.

TESTING AND TRACKING

(1) Jodrell Bank radio-telescope. (2) Fuelling a vehicle. (3) The Earth as it appears from 100 miles up. (4) A wind tunnel. (5) Test equipment for rocket booster with 1 million lb. thrust. (6) Engineers examining a space vehicle.



There was an illustration of test equipment for a new rocket booster with 1 million pounds thrust. Another photograph in this window looked at the Earth from 100 miles up. A complex system of tracking is rapidly encompassing our Earth. The Americans are planning to build a 400-ft. radio-telescope to dwarf the British telescope at Jodrell Bank, an illustration of which was shown in this window. The British Interplanetary Society report that three further radio-telescopes with 85-ft. parabolas together with minitrack stations in the northern and southern hemispheres will complete the network already commenced with the Equatorial stations.

In the past, Britain has not been backward in her contributions to space-flight and another window indicated a few of these contributions. Mr Ralph Smith, a past chairman of the British Interplanetary Society, was an original thinker on these lines and some of his drawings shown are still in advance of their time. Besides design studies of actual projects, many original ideas have been put forward in this country on engineering techniques which have found application elsewhere in the world. Also shown in this window was a model of the Mouse Rocket Project. Two ideas have been developed here: firstly, a rocket vehicle was designed, capable of launching a small instrumented satellite; secondly, satellites have been designed with miniaturised components which could transmit back scientific data. These ideas were, in fact, adopted for the initial satellite launchings by both America and Russia. Now, a variation which involves the use of an inflatable metal-foil balloon in the nose of a satellite, which can therefore be easily tracked, is to be adopted later this year. Factual illustrations of space-ships and space-stations could also be seen.

"Man in Space" was the theme of another presentation. Much of this work has been earth-bound with the aid of pressure chambers, centrifuges, rocket sleds and so forth, but the first men to circle the Earth in a manned capsule carried aloft in the nose of a rocket are already being chosen by the U.S.A. and U.S.S.R.

Other windows feature the Solar System and our Universe; our nearest neighbour the Moon, and our first target in space; a typical ascent in three stages, with factual data, details of every attempt made to date by the U.S.S.R. and U.S.A. in space exploration; the Solar System depicting the relative sizes of the planets and their relative distances in relation to the Sun, and factual information about the Sun, Moon, stars, and planets.

Foreign Members of the Royal Society

The following were recently elected Foreign Members of the Royal Society:

CALVIN, PROF. MELVIN. The University of California, Berkeley, California, U.S.A. Distinguished for his researches into the mechanism of photosynthesis.

DOMAGK, PROF. GERHARD. The University of Münster; and Director, Research Laboratories for Experimental Pathology and Bacteriology, Farbenfabriken Bayer, Wuppertal-Elberfeld, Germany. Distinguished for his researches leading to the discovery of Prontosil, the first chemotherapeutic agent against septic infection.

OORT, PROF. JAN HENDRICK. The State University of Leiden, Holland. Distinguished for his contributions to the knowledge of galactic structure, of stellar distribution and of stellar dynamics.

THEORELL, PROF. AXEL HUGO TEODOR. The Nobel Medical Institute, Stockholm, Sweden. Distinguished for his work in the field of enzyme chemistry, particularly in relation to oxidation in animal tissues.

2 FUTURE SPACE RESEARCH

The top picture shows an Alaskan tracking station. (1) Andromeda nebula. (2) Spiraen nebula. (3) Drawing of a possible space station. (4) A possible space vehicle drawn by Mr Ralph Smith. (5) A still from the film *The First Men on the Moon.*

***World Science Review* Ends**

We regretfully announce that it has been decided to cease publication of *World Science Review*; the April issue was the last. This has been made necessary owing to the fact that for some time the circulation of *World Science Review* has been such that it has been unprofitable and, of course, its losses have had to be borne by the other publications, *Intelligence Digest* and *The Weekly Review*. Both of these are profitable publications, but they could not indefinitely carry the loss incurred by *World Science Review*.

Expedition to Greenland

The Greenland Sukkertoppen Expedition will be in western Greenland during July, August, and September this year, under the sponsorship of the University College London Exploration Society. Contributions to this student's expedition have also been made by interested individuals, firms, and foundations.

Although many glaciers on the western fjord coast of Greenland have been recorded, they have never been studied in detail. There is a lot of ground around the glaciers which is not covered with ice and this provides an excellent opportunity for crypedological investigation. The expedition thus hopes to gain fresh information on certain crypedological formations.

The geological studies will be limited to that of the deformations in the younger intrusive rocks, or dolerites, in the region, the changes in mineralogy which accompany the deformations, and the influence of the dolerites on the deformation of the host rocks.

Errata

Prof. Bernal states that some errors appeared in "A New Theory of Liquids" (DISCOVERY, June, Vol. 20, No. 6, p. 230). First the statement "irregular dense packing of pentagonal arrangements are necessarily connected" should read "irregular dense packing and pentagonal arrangements are necessarily connected".

The two captions to the illustrations are also incorrect. On page 230, it is not a physical model of a molecule of liquid, but a physical model of arrangements of molecules in a liquid. In the other caption, these are not elements that go to make up a molecule but, again, the mutual arrangements of molecules in irregular dense packing.

Classified Advertisements

OFFICIAL APPOINTMENTS

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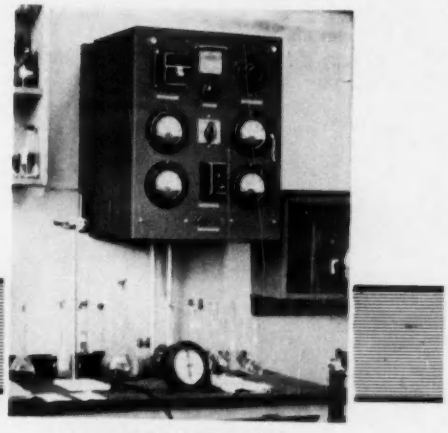

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